January 1947

TECHNOLOGY REVIEW

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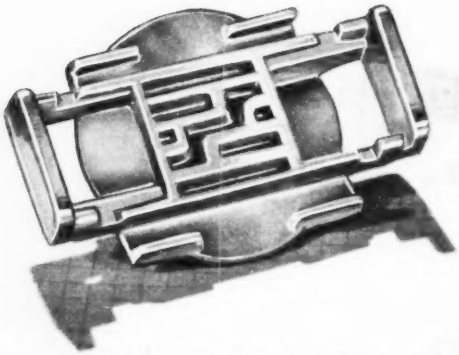
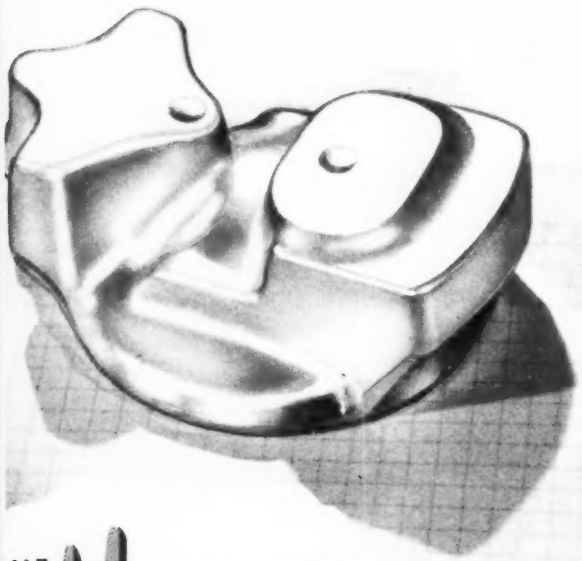


UNLIMITED APPLICATIONS



THE HARVEY METAL CORPORATION

HAROLD S. HARVEY '05 • *Engineers & Manufacturers* • SHERRY O'BRIEN '17

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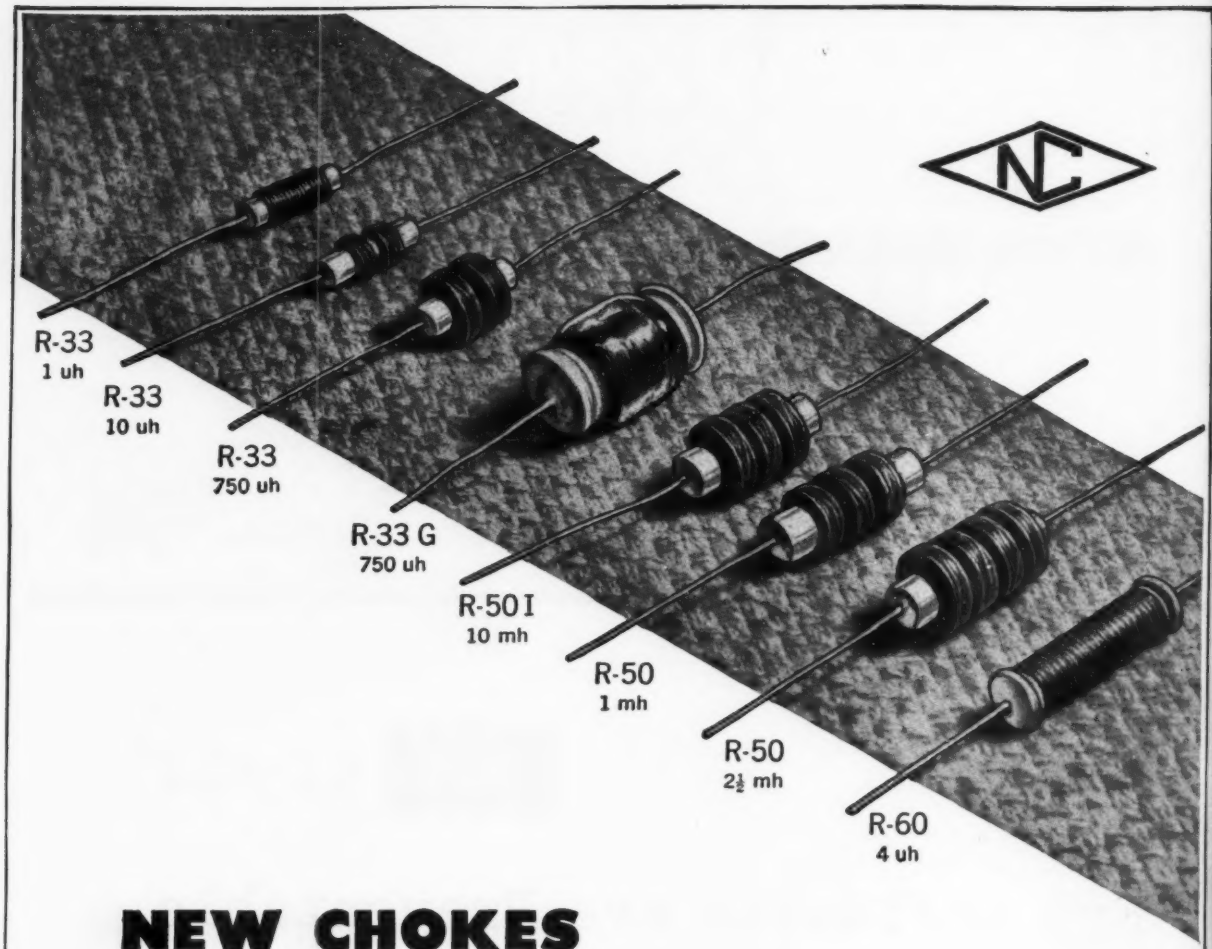
Send to your nearest A-O Safety Representative or direct to American Optical Company, Box T, for a copy of the new booklet, "Eye Accident Costs," which tells how much eye accidents cost, how to prevent them and how much you can save by preventing them.

American Optical COMPANY
Safety Division
SOUTHBRIDGE, MASSACHUSETTS
BRANCHES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, January, 1947. Vol. XLIX, No. 3. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

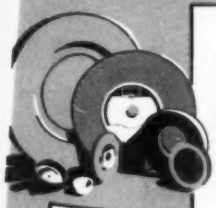


NEW CHOKES

The enlarged line of chokes now offered by National includes many new sizes and types and provides units suited to specialized as well as standard applications. Many popular new chokes are illustrated above, including the R-33G which is hermetically sealed in glass. Other models cover current ratings from 33 to 800 milliamperes in a variety of mountings carefully planned for your convenience. These as well as old favorites like the R-100 are listed in the latest National Catalogue.

NATIONAL COMPANY, INC., MALDEN, MASS.

Are You Acquainted with the WHOLE Norton Family?

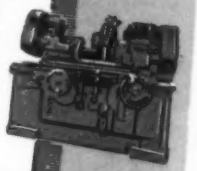


ABRASIVE PRODUCTS

Grinding wheels ranging from tiny internals 3/16 x 3/16" to the 72" diameter segmental type — wheels of Alundum°, Crystolon° and diamond abrasives, of many different bonds; a wide variety of abrasive bricks, sticks, hones and segments; mounted points and mounted wheels in nearly 200 sizes and shapes; abrasive grain for polishing, lapping and tumbling.

GRINDING AND LAPPING MACHINES

Norton cylindrical grinders range from the neat, compact 4 x 12" Type C to the gigantic 36 x 816" Type D and include special types for grinding crankshafts, camshafts, rolls and car wheels. Norton surface grinders are available in three sizes, 6", 10" and 12". There are three Norton Tool and Cutter Grinders and the Norton Bura-way. Lapping Machines range from the small 10-U to the large Hyprolap° for flat and cylindrical work, and include special machines for crankshafts and camshafts.



NORBIDE°

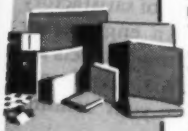
"The hardest material made by man for commercial use"— that is NORBIDE, the trade name for Norton Boron Carbide. It is serving industry in three forms: (1) Norbide Abrasive for grinding and lapping carbide tools, and for lapidary work; (2) Norbide Molded Shapes for pressure blast nozzles and for plug, ring and other types of gages; (3) Norbide Metallurgical Compound for improving the hardness and cutting ability of tool steels and as a deoxidizing agent.

PULPSTONES

Norton ingenuity developed for the pulp and paper industry a line of segmental stones running as large as 72 x 54" and weighing up to ten tons — stones that convert the logs of the forest into wood pulp for newspaper, wall paper, towels, toilet tissue, cartons, wall board, paper plates and countless other uses.

NORTON FLOORS

The hardness, toughness and abrasive properties of Alundum abrasive are made use of in NORTON FLOORS — Alundum Stair and Floor Tile, Alundum Ceramic Mosaic Tile and Alundum Aggregate for terrazzo and cement floors. They are for use in public and commercial buildings wherever it is necessary to provide floors and stairs with an extremely wear-resisting and permanently non-slip surface (wet or dry).



POROUS MEDIUMS

Norton Porous Mediums are made in a wide variety of shapes and rates of permeability for the aeration, filtration and diffusion of liquids, solids and gases. Important uses are in activated sludge sewage disposal plants, for municipal water filtration plants and in many commercial filtration and aeration processes.

REFRACTORIES

The terrific heat of the electric furnaces which produce Alundum and Crystolon abrasives also gives these materials valuable refractory properties — properties which are made use of in a complete line of Norton refractory grain, cements, bricks, plates, tiles and other shapes for metal melting and heat treating, for enameling furnaces, ceramic kilns, boiler furnaces, gas generators; also refractory laboratory ware for ignition, incineration and filtration.

Informative literature in any or all of these Norton products available on request — also Norton engineering service. Write today.

° Trade-marks registered U. S. Patent Office

NORTON COMPANY
WORCESTER 6, MASS.

OILSTONES AND COATED ABRASIVES

Oilstones and sharpening specialties in sizes and shapes to meet every need of the industrial worker, the farmer and the home craftsman; and abrasive paper and cloth in a wide variety of coatings and types for both industry and the home mechanic are available through the Behr-Manning Corporation of Troy, New York, Division of Norton Company.

NORTON

6 IN A ROW...

6 THERMAL "CRACKERS"... INITIAL RUNS OF MORE THAN 30 DAYS!

A long initial run is the forerunner of satisfactory performance in the long run. An engineering and construction organization whose projects are characterized by long initial runs is, therefore, a good one to build or modernize your refining facilities.

Among the long initial runs which have characterized Lummus construction are those of six thermal cracking units. In chronological order, the initial runs on these units were 33, 35, 39, 49, 65 and 69 days. In each instance the plant was shut down for inspection purposes only.

The latest Lummus catalytic cracking plant ran 240 days on its initial start-up before it was shut down for inspection.

A reputation for long initial runs is only one index by which to judge Lummus engineering and construction. Other indices are: *experience* — Lummus has built over 600 plants throughout the world; *process development* — Lummus pioneered the commercial development of a number of processes now standard; *research and development facilities*—Lummus has complete laboratory and pilot plants for refinery development, plus broad experience required to prepare economic studies of proposed installations.

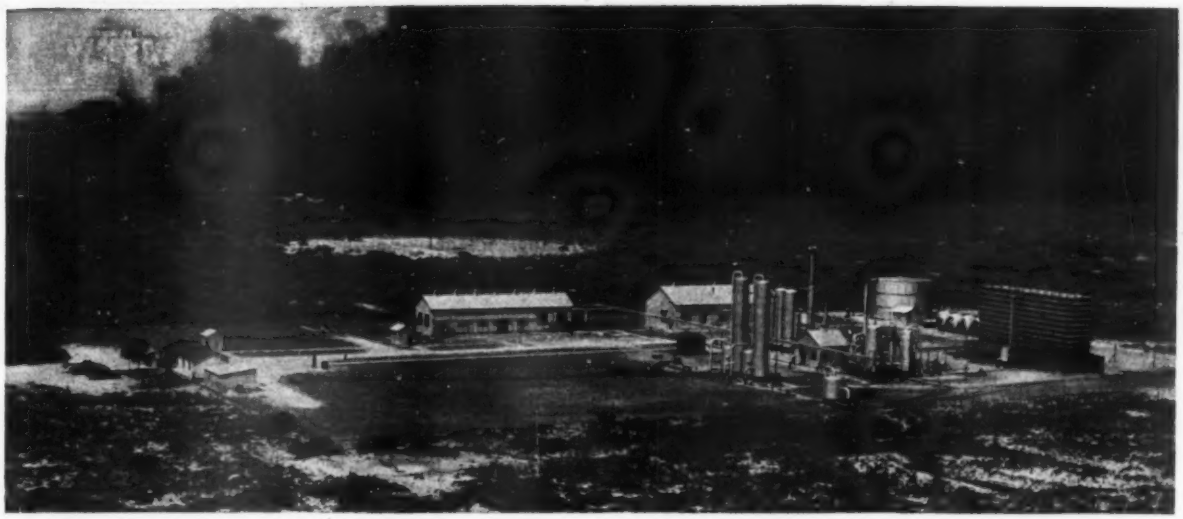
Lummus engineers are available for a discussion of the technological and economic considerations of refinery modernization or new plant construction.

THE LUMMUS COMPANY

420 Lexington Avenue, New York 17, N. Y.

LUMMUS Petroleum Processes and Plants
CHICAGO — 600 South Michigan Avenue, Chicago 5, Ill.
HOUSTON — Mellie Esperson Bldg., Houston 2, Texas
LONDON — 78 Mount Street, London, W. 1, England

Lummus
PETROLEUM REFINING PLANTS



FOR INDUSTRY

Carbon Black
Natural Gas
Natural Gasoline
Pumping Equipment
Pine Tar
Charcoal
Carotene
Chlorophyl

And for conservation too, as these two consecutive Cabot operations in the West Texas oil fields demonstrate. These plants are treating casinghead gas, the "sour" gas whose sulphur content destroys its ordinary industrial value. It is the waste gas which once was blown off in the air or burnt at the wells as a dangerous nuisance.

The Cabot Carbon Company puts this same gas to further valuable uses. First, Cabot plants like Keystone, shown above, strip it of its natural gasoline for the enrichment of distilled motor fuels. Propane and butane also are extracted.

Next, this same gas is burnt at plants like Cabot's Kermit, in the background, in the manufacture of carbon black for rubber, paint, varnish, lacquer and ink. Yet carbon black, natural gasoline, butane and propane are only four of the raw materials which the group of Cabot Companies provides for industry.

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TEXAS ELF CARBON CO.
GENERAL ATLAS CARBON CO.
CABOT SHOPS, INC.
VALLEY VITAMINS, INC.

CABOT

GODFREY L. CABOT, INC.
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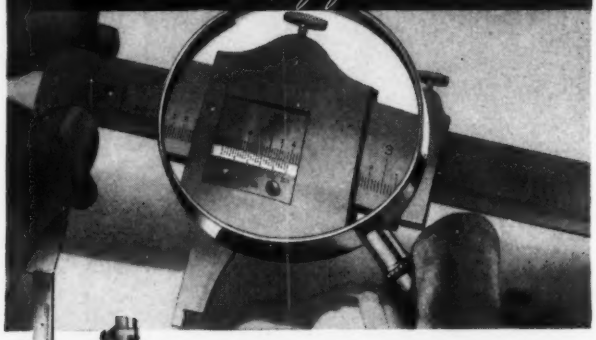
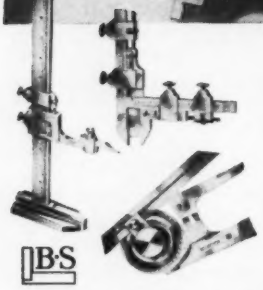
. . . a mark of fine tools





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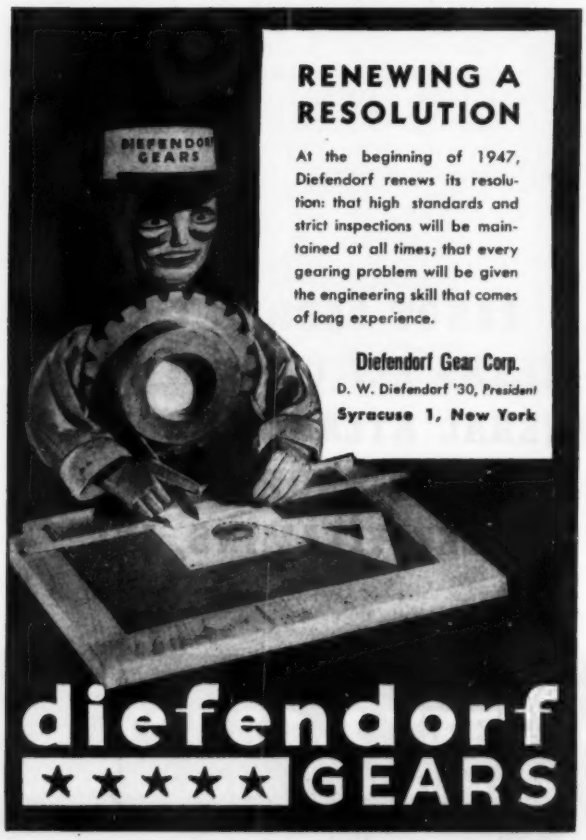
Brown & Sharpe has always put into fine machinists' tools the largest possible measure of good workmanship, fine materials, and sound design. For example, the machine-divided graduations on Brown & Sharpe Vernier Tools.

Brown & Sharpe machinists' tools give every purchaser a generous return on a sound investment. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

RENEWING A RESOLUTION

At the beginning of 1947, Diefendorf renews its resolution: that high standards and strict inspections will be maintained at all times; that every gearing problem will be given the engineering skill that comes of long experience.

Diefendorf Gear Corp.
D. W. Diefendorf '30, *President*
Syracuse 1, New York



diefendorf
★★★★★ GEARS

THE TABULAR VIEW

American Sidewheelers. — H. E. Lobdell, '17, Executive Vice-president of the Alumni Association and publisher of the Technology Review (whose biography appears in greater detail on pages 104–105 of the December issue) brings to this issue a product of his hobby of stamp collecting. Based on a study of the postal history of foreign ports in China and Japan, *Orient Mails "Via Pacific"* (page 151) deals with significant matters of trade and technology in opening the Orient to American commerce and mail some eight decades back. A definitive article, emphasizing the postal aspects of the same study, has appeared by Mr. Lobdell in the yearbook of the Twelfth American Philatelic Congress.

Antibiotic Metabolites. — As sequel to his article on penicillin in the March 1944 issue of The Review, Dr. Rudolf E. Gruber, '16, discusses recent advances in the production and use of penicillin and streptomycin (page 155). From his vantage point as Vice-president of Merck and Company, Dr. Gruber speaks with authority of intimate knowledge of these two war-developed therapeutics, whose beneficial results have attracted widespread comment.

Dust Removal. — Well known to Review readers as a Swiss-trained engineer, Dr. Sigfried Giedion has returned to Zurich after spending several years in the United States carrying on research for his new book — soon to bear the imprint of Oxford University Press — in which he surveys the impact of mechanization on the culture of our times. *Vacuum in the Home* (page 157) is excerpted from the section dealing with origins, premises and trends of mechanization in the household, with the permission of the publisher and the co-operation of Dr. Giedion's American representative, James Martin.

Absolute Zero. — Having taught physics and chemistry at several universities — including M.I.T. where he joined the department of chemistry in 1930 — S. C. Collins is now associate professor of mechanical engineering and deeply engrossed in low temperature research. Recent research which Dr. Collins records (page 161) opens up new industrial operations by making available large quantities of oxygen at low cost. The greatest significance of his work, however, is undoubtedly the new knowledge of the behavior of matter which will come to light with the creation of new techniques for working at temperatures near absolute zero.

Speed with Economy

We are now working on our 38th contract for

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Alfred T. Glassett '20, Vice President

HANNIBAL'S FROZEN ASSET

The Romans smugly thought the icy barrier of the Alps impassable. But Hannibal turned the paralyzing cold to his advantage. He had water poured into the crevices of road-blocking boulders. The expansion of the freezing water "made little ones out of big ones"— and another road led to Rome.

Low temperature, which worked to Hannibal's advantage, is a distinct disadvantage to operating machinery. Under low temperature conditions, some steels that may perform perfectly at ordinary temperatures, develop unsuspected weakness. There is always danger of a parts failure under such conditions.

One way to assure good performance at low temperatures is to specify molybdenum steels. Good hardenability plus freedom from temper brittleness give them good low temperature impact strength. They are a precaution it pays not to ignore. Practical working data are available on request.

MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

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MOLY

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WITH 12000 SERIES LEVEL CONTROLLERS

Transmitter Pilot
Zero Setting Index — for adjustment of normal zero. Adjusting screw is locked after setting.
Specific Gravity Scale — calibrated from 0.5 to 1.2 or from 0.8 to 2.0 specific gravity.
Controller Pilot
PNEUMATIC TRANSMITTER
LOW
HIGH
Resistance Unit—Scale is calibrated over a 10-inch length. Simplified assembly and precision machining for reproducible settings. Stainless steel plug and orifice.
Proportional Band Scale—calibrated from 2 to 100% over 4-inch length. Linear proportional characteristics to close limits in all settings.
Specific Gravity Scale—calibrated from 0.5 to 1.2 or from 0.8 to 2.0 specific gravity.
Setting Index Scale—provides control point setting through full level range. Vernier knob for smooth and positive adjustment.

The 12600-20 Series of Level Controller-Transmitters have been developed in order to provide level indication or recording in addition to the primary function of controlling level. The Controller-Transmitter provides increased flexibility to meet process requirements.

CONTROLLER MECHANISM — available with either proportional (12600-20) or proportional-reset (12610-20) action. All features of the basic controller have been retained, e.g. the easily calibrated specific gravity scale, the proportional mechanism, the large capacity balanced pilot, the vernier control point setting, the reversible control action.

TRANSMITTER MECHANISM — operates from the same measuring element, that is, from the same displacer and torque tube assembly. Otherwise, it is completely independent from the controller mechanism. Separate supply and output gauges have been provided to simplify operation and servicing.

FEATURES

Unit Construction — The parts which constitute the control mechanism (i.e., the proportional mechanism, including the cantilever spring, nozzle, flapper, bellows and control arm, the pilot and the air manifold) are complete sub-assemblies and are independent of the case.

Pilot — The large capacity pilot is fastened directly to the air manifold by means of two screws, eliminating any major air tubing connections and facilitating removal. Simplified construction permits disassembly in the field for cleaning.

Air Passages — All air passages are bronze or copper, preventing the formation of scale or rust beyond the air filter in the supply line.

Knife-Edge and Flexure Bearings — The lost motion and friction is reduced to such a point by the use of knife-edge and flexure bearings that the response to changes in level is practically instantaneous.

Torque Tube Sub-Assembly — All parts of the torque tube sub-assembly are of inconel and are fused together by the atomic-hydrogen arc welding process. Monel and stainless steel assemblies also available.

MASONEILAN

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"Our knowledge is the amassed thought and experience of innumerable minds"
—RALPH WALDO EMERSON

Why some things get better all the time

THE OLD-FASHIONED STOVE has warmed many a generation through the years. But today families are kept healthfully warm by far more effective means.

There are electric heaters and electric blankets with their efficient alloy heating elements. Individual gas fuel installations. Improved heating systems for our homes, ranging from oil burners with fuel nozzles of long-lasting synthetic sapphire to the new panel heating with its welded piping. Also giving you finer service are better insulated electrical wiring, vast central heating systems, and city and cross-country gas lines.

Far-reaching are the improvements in heating and power enjoyed by families today . . . And most of these improvements are possible because of *better materials.*

Producing better materials for the use of industry and the benefit of mankind is the work of UNION CARBIDE.

Basic knowledge and persistent research are required, particularly in the fields of science and engineering. Working with extremes of heat and cold—frequently as high as 6000° or as low as 300° below zero, Fahrenheit—and with vacuums and great pressures, Units of UCC now separate or combine nearly one-half of the many elements of the earth.

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GOOD NEWS *from General Electric*

FOR CAR OWNERS

. . . a new lifetime finish

A finish that will retain its original brightness and gloss as long as your car lasts—that is the goal which General Electric chemists hope to reach with silicone resins, the new materials derived from sand.

They predict that the finish will be perfected within five years.

The paint is already under test. It has proved highly resistant to severe weather conditions, chemicals and heat. Immersed in acid and alkali solutions that would cause today's finishes to deteriorate, silicone-treated panels have remained unmarred.

FOR SMOKERS

. . . leakproof cigaret paper

A new G-E fault detector makes possible the production of a cigaret paper that is virtually leakproof—free of those pesky little holes that sometimes cause a cigaret to draw improperly.

Not only holes but minute imperfections in the paper are detected electronically by the instrument.

In addition to adding to smokers' pleasure, the new device will be used industrially for inspecting paper, sheet rubber, sheet mica, plastics and other materials.

FOR TRAVELERS

. . . peacetime radar

Radar is being used both on ships and planes to cut down the hazards of traveling in the dark, in fog, or in storms.

For planes, the General Electric Electronics Department will soon produce a radar unit weighing only about 100 pounds, designed to increase the efficiency of "all-weather" airline operations.

For ships there is the G-E "electronic navigator," which uses radar to detect the position of above-water obstacles.

FOR G-E EMPLOYEES

. . . life incomes after retirement

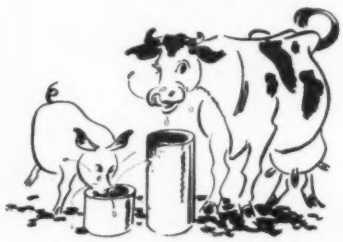
A steady life income after retirement is offered all G-E employees under provisions of a hundred-million-dollar pension plan recently announced by General Electric.

For the average employee this will mean a retirement income several times as large as the annuity he could ordinarily buy. Income at retirement, when added to Social Security payments, will amount to about 50% of average pay for the employee who has spent his working years with the Company.

Other G-E "job dividends," those extras that employees get in addition to wages, include insurance, vacations with pay, and achievement awards.

FOR FARMERS

. . . a stock drinking cup



One of the latest direct applications of electricity to the farm is an electrically heated automatic stock drinking cup. A clean, fresh, year-round, outdoor water supply for livestock is now possible with this drinking cup.

Designed for use in sub-zero weather, it consists of a Calrod-heated drinking cup, enclosed in a durable metal housing, and fed from the farm water supply system by an electrically heated water pipe. Livestock simply nose down a treadle in the base of the cup, causing water to flow automatically.

A thermostat automatically maintains the water in the cup and pipe at a temperature safely above freezing.

FOR HOMEMAKERS

. . . the Circline lamp

The Circline lamp is a circular fluorescent lamp. A 32-watt bulb of this type gives as much light as a 100-watt incandescent lamp.

These lamps, which set a new style in lighting, shed a soft, cool light from a diffused area instead of a single lighting point.

GENERAL ELECTRIC

PROPOSED CHILDREN'S MEDICAL CENTER, BOSTON, MASS.

CASE FOR A SPECIALIST....

Our broad experience and specialized knowledge in every phase of engineering and construction often are employed during the period of preliminary planning as well as for actual construction of institutional buildings.

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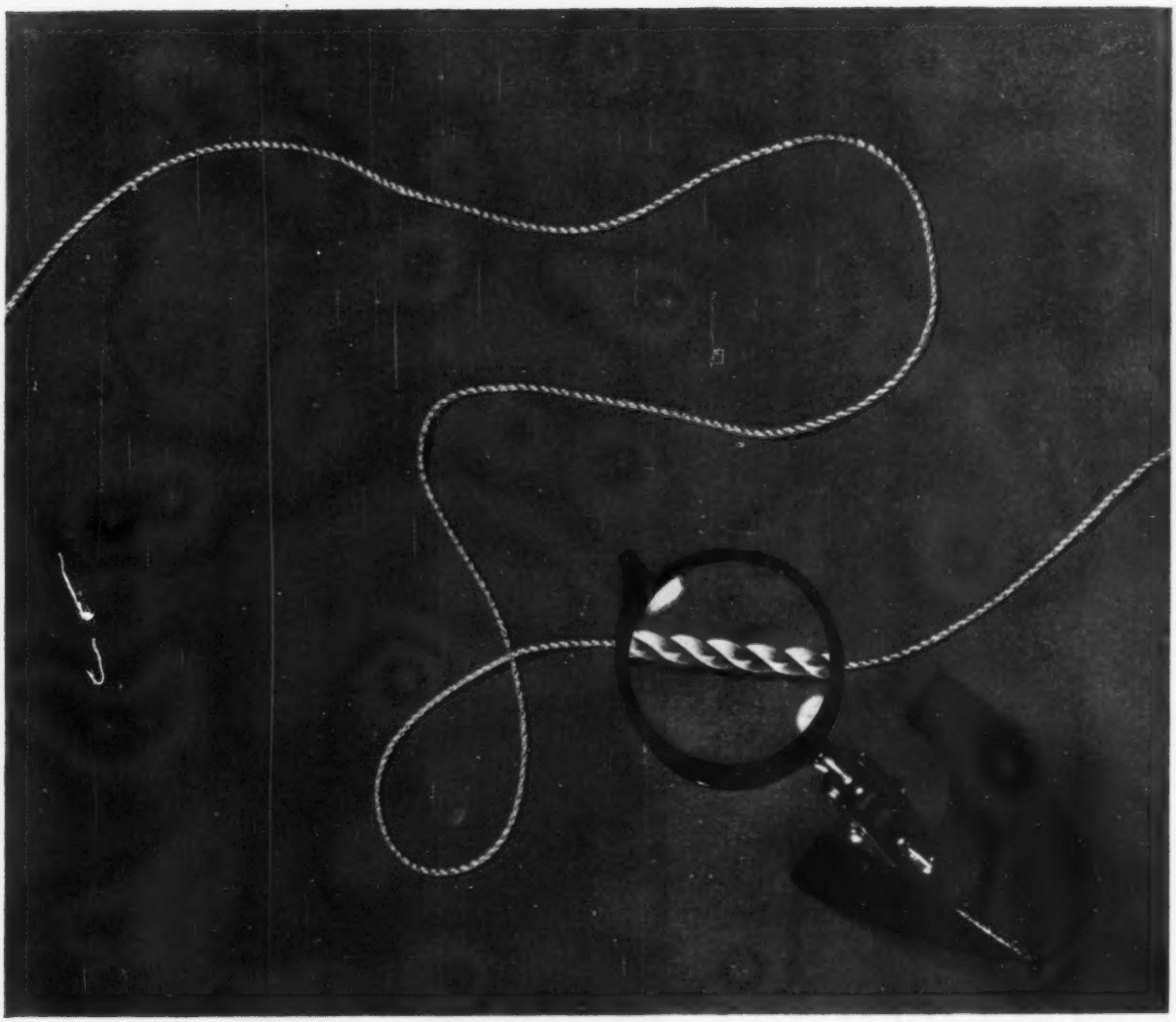

It's the wonderful new twist to tire mileage!

ANOTHER REASON FOR GOODYEAR LEADERSHIP

You are looking at a picture that began almost 20 years ago — when Goodyear first experimented with rayon cord for tires.

That was the initial step. Over 15 years ago, Goodyear built the first rayon cord tire — perfected it — and when war came Goodyear was ready. Goodyear truck tires — made of rayon cord — helped speed supplies in the battle for Europe.

Today, from these strands of rayon cord are being built thousands of Goodyear passenger tires that set new records for mileage, safety, and economy!

Rayon cord tires are another in a long line of Goodyear "firsts" — the Straight-Side Tire, the Multiple-ply Cord Tire, the All-Weather Tread, the LifeGuard Safety Tube and many others. These, over the years, have made your tires last longer.

Goodyear goes right on working to benefit you — not just tomorrow, but ten years from now. It is this never-ending search for something better that helps explain why it's true today — as it has been for 32 straight years — "More people the world over ride on Goodyear Tires than on any other kind."

A pioneer in rubber, and the world's greatest tire company, Goodyear also has broad experience in many other fields — metals, fabrics, chemicals, plastics — constantly developing new products that will serve you better.

GOODYEAR

THE GREATEST NAME IN RUBBER

W. LaVarre, from Black Star

"Let's Eat"

VOLUME 49 NUMBER 3

THE TECHNOLOGY REVIEW

TITLE REGISTERED U. S. PATENT OFFICE

EDITED

AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Official photograph, National Advisory Committee for Aeronautics

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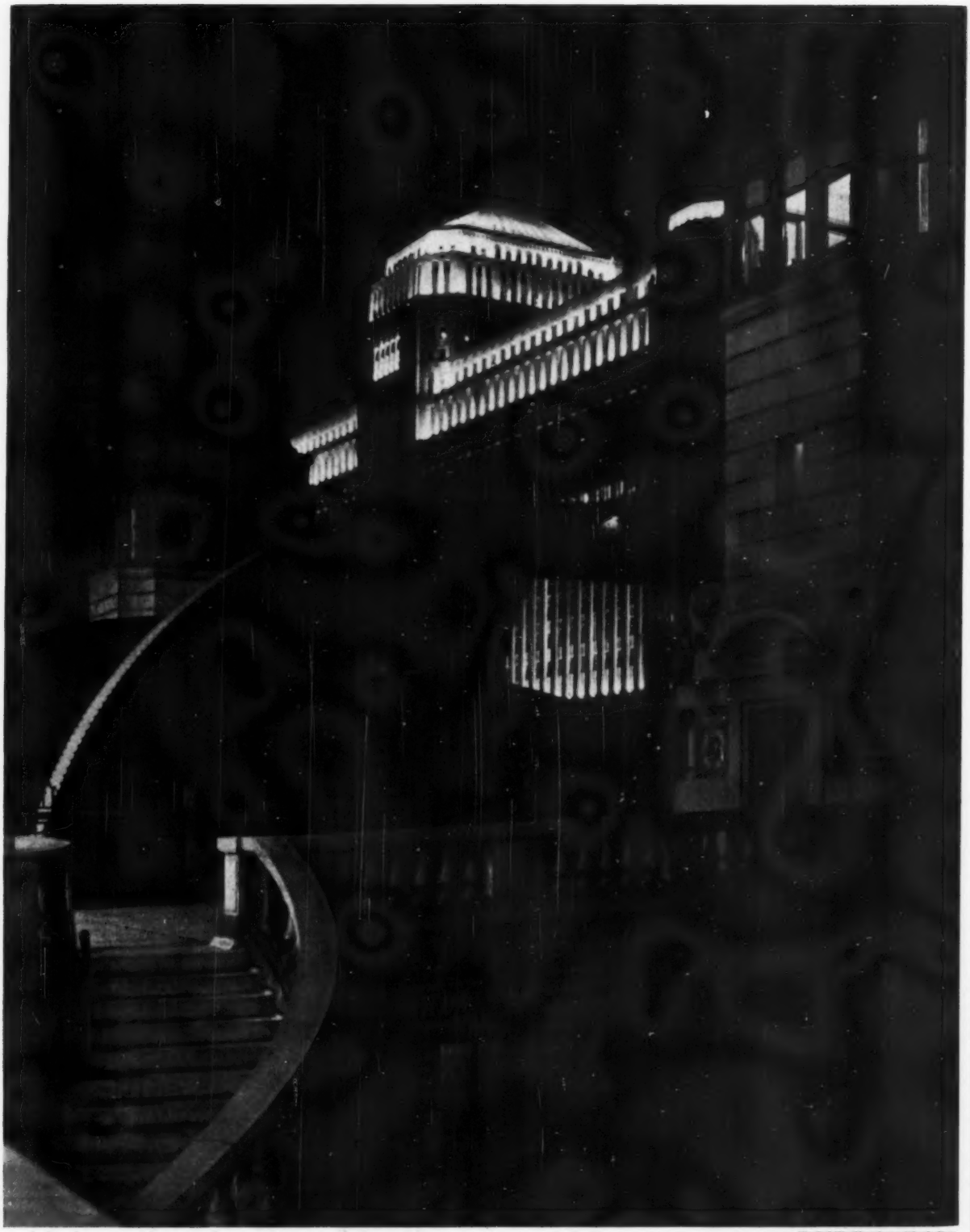

Torkel Korling from Black Star

Night Sentinels

"But they, while their companions slept, were toiling upward in the night."

The Ladder of Saint Augustine — Henry Wadsworth Longfellow

THE
TECHNOLOGY
REVIEW

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The Trend of Affairs

Prospect and Retrospect

IN keeping a time-honored tradition, we close the old year with retrospective glances at past achievements and look to the coming of the new year with the perennial hope that it will constitute a brighter chapter in the world's history. It is well that we take stock, from time to time, of the progress that has been made in many fields. By viewing recorded experiences, we shall find a springboard to the progress of tomorrow.

The year 1946 saw less accomplishment in the fields of international peace and industrial good will than might have been desired. Conspicuous was a restless insurgence, characteristic of post-war reconversion eras. Yet, in spite of altercations concerning international and industrial issues, of annoying shortages of food, clothing, and shelter, of our inability — or unwillingness — to forge ahead in reaching our vast production potential, there were luminous spots in the year's activities. A wave of adults seeking education absorbed facilities of the country's colleges, many wartime restrictions and controls were rescinded, and aggressive wars were placed in the category of criminal activities by an international tribunal. Substantial gains were made in science and in technology, a few of which will receive proper attention after a rekindling of the highlights of achievements made during years ending in 7. Progress in mechanical inventions and in the development of electricity are of such import as to be singled out for special mention.

As far back as 1797, David Wilkinson invented the gauge and lathe and in the same year Charles Newbold was granted a patent for the first cast-iron plow. Two decades later George Clymer invented the bicycle and the first machine-made paper produced in this country came from the paper making machine of Thomas Gilpin. In 1837 Henry Crawford of England, made a considerable contribution with his process of galvanization which greatly reduced rust formation.

An even century ago this coming year, the Bessemer process for making steel was invented and David Smyth devised a machine for making books. The patent for a harrow, issued on August 7, 1847 to G. Page, showed a single revolving disc on one side of the plow.

The genius of Charles Webb gave the world the adding machine 80 years ago; the same period saw the invention of the four-cycle gas engine by N. A. Otto. In 1867 Burdsall Hooley conducted the first successful experiments in central heating by transmitting heat through pipes for a distance of 100 feet from his home.

Germany held the spotlight 50 years ago with three important inventions. In 1897 Goldschmidt invented the thermit process, Walter Nernst evolved the lamp named after him, and the Diesel internal combustion engine came into being.

Many significant contributions to electrical technology were brought to light during years whose last digit is six plus one. Just 200 years ago, Benjamin Franklin wrote of his experiments with the electric kite, from which he deduced the electrical nature of lightning. At the same time he also proposed his single fluid theory of electricity in which the two states of electrification then known were regarded not as the result of two different fluids but as an addition or subtraction of a single fluid. In modified form, Franklin's concept prevails today. Franklin's superlative gift for accomplishment was again displayed in 1757 with the invention of the lightning rod.

During the Nineteenth Century electricity was transformed from an interesting curiosity to a powerful agent that would subsequently become the backbone of our industrial way of life. Sir Humphrey Davy announced the electrical decomposition of potash and soda from which he obtained potassium and sodium in 1807. Two decades later George Simon Ohm in Germany published his celebrated paper in which he introduced a clear idea of the relationship between the current and the electromotive force in a circuit containing resistance. Also in 1827 an interesting and curious observation was made by Felix Savart who found that a needle magnetized by the

discharge of a Leyden jar would sometimes show the north-seeking pole at one end of the needle and at other times at the other end.

In England in 1837 Michael Faraday endowed electric charges with new garb by surrounding them with lines of force. The sine and tangent galvanometers, invented by C. S. M. Pouilet of France in the same year were certainly among the earliest of electrical measuring instruments. The third outstanding development of that year occurred in the United States; Samuel F. B. Morse disclosed his idea for an electric telegraph system.

Exactly one century has passed since Helmholtz prepared his paper on the conservation of force, extending to all the domains of physics, a concept developed five years earlier by Mayer. On March 5, 1857, Alexander Graham Bell was born.

Disaster overtook the first Atlantic cable which broke on August 11, 1857 while being laid, but ten years later William Thomson (who had not yet acquired the title of Lord Kelvin) advanced communication over the cable by his invention of the siphon recording receiving apparatus. The year 1867 also saw extensive distribution of the first paper by James Clerk Maxwell and accounting for all electric and magnetic phenomena.

Thomas Alva Edison dominated electrical developments by 1877. In that year he invented the mechanical phonograph as well as the carbon microphone, and the Edison Electric Company of New York was being organized to generate and distribute electric power. Six decades back Heinrich Hertz had discovered that ultraviolet light acted as a conductor of electricity, and Nikola Tesla had invented the polyphase electric current system of power transmission.

The first account of the electron and its properties was given in England by J. J. Thomson half a century ago at the time when Guglielmo Marconi of Italy developed the first practical system of wireless telegraphy. In January 1907 Lee DeForest was granted a patent for his three-element electron tube — a device which was to become the cornerstone of electronics. In the same year DeForest is credited with having been the first to use the carbon microphone in experiments with radio telephony. The year 1947 will mark the twenty-fifth anniversary of the beginning of commercial broadcasting (on a wide scale) in the United States.

Having advanced to events of the Twentieth Century, we stop briefly to record three events in the communication field which took place in 1927. The Bell Telephone Laboratories gave the first demonstration of television apparatus to operate over any considerable distance with the simultaneous transmission of aural and visual signals between New York and Washington. This was also the year in which radio receiving sets designed for complete alternating current operation were introduced, the Federal Radio Commission was established to regulate the radio industry, and the Columbia Broadcasting System was formed.

We conclude this survey by reviewing a few significant developments recorded during the past year. In the field of aviation, supersonic waves were used successfully to convert fog into rain for clearing landing fields. An instrument, called the cloud detector, was devised to make night flying safer by measuring the infrared radiation from clouds. A system of push-button flying that enables airplanes automatically to take off, fly, and land safely was also demonstrated. . . . In atomic physics, mesotrons — the particles which are believed to hold the atom nuclei together — were accurately measured for the first time and were found to have a mass 202 times that of an electron. . . . Developments in electronics were advanced by the invention of a new vacuum tube amplifier, called the travelling wave tube, which gave promise of greatly increasing the amount of information that could be transmitted simultaneously over communication channels, and the magnifying power of the electron microscope was doubled by an improved magnetic lens which makes possible the distinguishing of particles separated by a mere 50 billionths of an inch. . . . Most spectacular radar development of the year was the transmission of signals to the moon and the reception of the echo after a lapse of 2½ seconds for signals to make the round trip. . . . In the radio field, radiotelephone equipment was installed in taxis, buses, and service trucks. Radio beams were focused into a sharp beam by a metal lens antenna used in micro-wave systems, and facsimile transmission of pictures and printed material was accomplished between Boston and New York. . . . When Congress passed the National Mental Health Act, which recognizes mental health as a serious problem worthy of public support and appropriations, it opened the doors for further improvement of the public's health. An aid to the deaf was given by the invention of the sound spectrograph, a device by which sounds are reconverted into visual patterns that can be read and interpreted as speech. The blind were equally benefited; an electronic seeing eye which is capable of detecting the distance and direction of objects within a distance of 20 feet is more than a worthy invention.

The technical and scientific achievements of the past year are indeed gratifying, and it is with deep interest that the work of science in enriching the world will be watched during the coming year. Would that man also recognize his obligations toward civilization and individually take active part in the establishment of a permanent peace. *De nihilo nihil fit.*

Photo by H. Armstrong Roberts

It doesn't take many monkey wrenches to put our complex industrial machine badly out of synchronization.

The Record

OPENING with what was probably the most extensive wave of strikes in the history of the United States, the year 1946 draws to a close facing the threat of a new period of unrest. Particularly after a war there is nothing new in the jockeying for economic advantage between management and labor, and the liberal use of labor's basic weapon — the strike. More than four million men were involved in 3,600 strikes in the United States during 1919, a year which was marked by unusual industrial unrest in Great Britain and Germany as well as in this country. By 1923, however, the various indices of labor-management strife had subsided to a level which was more or less average for the between-war period. Using the years 1920 to 1938 as a base, this country had an average of 1,660 strikes, involving 800,000 workers each year.

With the returns in for only the first ten months of 1946, it is certain that this year will be marked by a record number of strikes and strikers. Probably a more revealing statistic, however, is the number of idle man-days resulting directly from strikes, a figure which has been available only since 1927. For the pre-war period of 1927 to 1938, the average loss per year was about 14,000,000 man-days, a figure which averaged about 11,000,000 man-days per year during World War II. Since the end of the war, industrial strife has skyrocketed to the extent that each of the first four months of 1946 could boast the dubious distinction of equalling or exceeding the 1927–1938 annual average. In fact, the combined figures for January and February 1946 show a larger total of idle man-days than that of any previous year. The 102,525,000 idle man-days accumulated up to the end of October (a figure unparalleled in American history) can be compared only to the 162,000,000 man-days lost in Great Britain in 1926, the year of the general strike.

Obviously the figure of man-days lost does not give a complete picture of the production losses imposed by strikes. In February, the most strike-bound month for which 1946 figures are available, the idle man-days resulting from strikes represented but 3.94 per cent of the total available working time, compared to less than one per cent in normal years. Even though the absolute value of the losses represented by these percentages is huge, of themselves, they would not appreciably alter our indices of production. But as strikes increase in duration and extent, losses snowball in exponential fashion and the consequences are particularly severe when an entire basic industry is affected.

Photo by Keystone View Co.

The productivity of labor determines the size of the economic pie that the American people produce and divide.

The trucking and shipping strike, from which New York City has but recently emerged, provides excellent example of the geometric progressions which may ensue as a result of industrial disputes between obdurate groups which are not numerically significant. Probably not one per cent of New York's working population was engaged in the trucking and shipping strike, but for eight weeks inbound railroad freight was cut to about one-fifth of its normal volume and, at the same time, outbound freight was cut almost in half. The monetary losses for the city are estimated at $1,500,000,000 — well beyond $100 per capita for New York's population and more than $10 for every man, woman, and child in the United States. Such a sum would be sufficient to operate M.I.T. for a period of 150 years at its present $10,000,000 budget for 1947, or it might have operated M.I.T. and the Radiation Laboratory for 37½ years at the war-time peak of $40,000,000 expended in 1945.

American labor has entered the post-war era at a peak in numbers, in organized strength, and in legal standing. It strives to retain and improve its economic position — a function in which every segment of our economy engages. In some of the more important strikes of the first nine months of 1946, laboring groups have pitted 200,000 automobile workers against the General Motors Corporation, 200,000 electrical workers against the Westinghouse Electric Corporation, the General Electric Company, and the General Motors Corporation, 190,000 men against the packing houses, 700,000 persons against the steel industry, 150,000 maritime workers against the ship lines, and 350,000 bituminous (not to mention 75,000 anthracite) coal miners against the solid fuels industry.

This year's strikes have not only involved an unusually large number of persons; many of them have also been unusually long. During the early part of the year, quick settlements for wages, based on what labor could get for its work and the price industry could ask for its products in a free market, were frequently hindered by the continuation of wartime price controls. But many other issues were involved, some of them far more important to the future relationships of management and labor than any immediate question of money. With both management and labor in relatively good condition to withstand the losses of prolonged strikes, it is not surprising that some battles ensued — battles in which consideration of the public interest often was conspicuously lacking.

Not without creating resentments which some day will have to be corrected, one by-product of these struggles has been a tendency for the wages of organized groups of employees to rise at a faster rate than those of traditionally higher ranked groups — teachers, engineers, technicians, and other white collar skilled employees. The paralysis of wide-spread industrial operations, or the forced unemployment of hundreds of thousands of workers by a comparatively few strategically placed obdurates, has focused attention on another by-product; the increasing disregard of public welfare and the growing lack of self-control inimical to the philosophy and practice of

democracy. Although not yet marked by sufficient progress to have much bearing on current disputes, increasing attention has been directed to a third by-product — a technological one which seeks substitutes for strike-bound services and products.

That strikes have not cleared the air in all cases is indicated by complaints in some industries that worker productivity is falling, thereby reversing a trend of long standing in the United States. In part, this is probably a temporary phenomena, associated with reconversion and with interruptions in the flow of materials and sub-assemblies resulting from strikes and from the chaotic relationships of supply and demand. It doesn't take many monkey wrenches to put our complex industrial machine badly out of synchronization. But that part of the drop in production which is due to bitterness and suspicion between labor and management calls for immediate attention.

Before the war broke out, administrators were beginning to give widespread and deliberative thought to the factors which determine worker morale, of which finances are but one aspect. There is evidence that this trend is being resumed, and that we are on our way to make sound human relationships in industry the first task of management. But — as is so ably brought to light by Paul W. Litchfield, '96, in his rational and thought-provoking volume, *The Industrial Republic* (Corday and Gross) — this objective must be sincerely sought by both disputants, for no real progress can be made so long as either side is forced into a policy of appeasing the other.

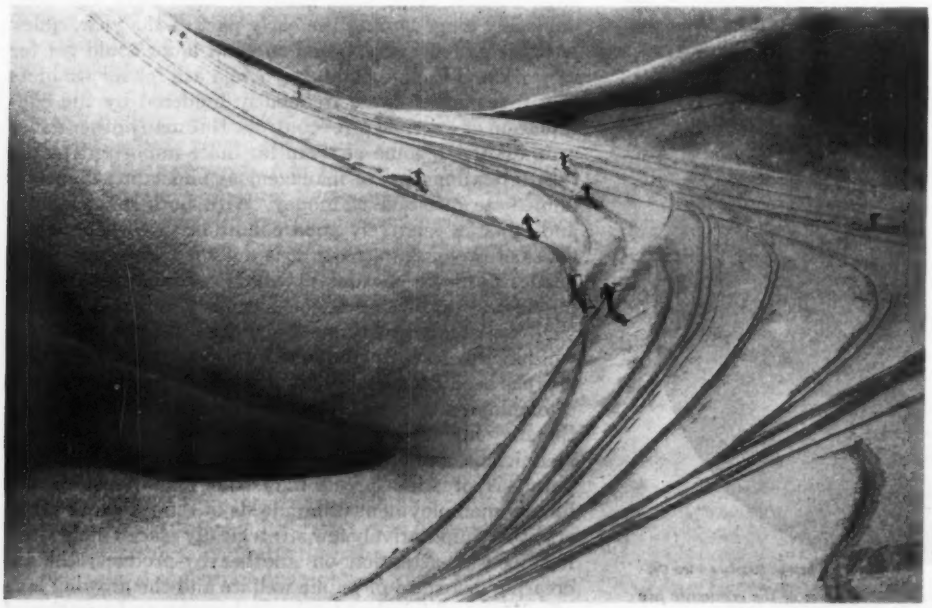
In thumping the barrel head of social gains, it is easier to obtain a following by advocating higher wages than by advocating the less materialistic concept that, in a democracy, the welfare of the general public has a higher priority than that of any minority group, however powerful. But even this purely dollars-and-cents appeal can be overworked. The productivity of labor determines the size of the economic pie that the American people produce and divide, and for any group a larger piece of a smaller pie may turn out to be no bargain.

124 Man-Years to M.I.T.

FERRIS GREENSLET'S latest best seller, "The Lowells and Their Seven Worlds" (Houghton Mifflin), contains a half chapter devoted to the distinguished architectural career of the late Guy Lowell, '94, whose professional achievement culminated in the 15 years between 1912, when he won the competition for the great new Court House for the City of New York, and 1927, when the completed building, described as "a hexagon instead of the full circle, the amphitheatre of his first conception," was dedicated a week after its architect's death. Technology interest in this felicitously compounded volume, however, depends not alone upon the fact that Guy, after four years preparation at Harvard College, matriculated in 1892 at M.I.T. from which two years later he received an S. B. degree in architecture under the guidance of Francis Chandler and Desire Despradelle before proceeding overseas to the École des Beaux Arts; nor upon the fact, which escaped Dr. Greenslet's notice, that Guy was a member of the Institute's instructing staff from 1899 to 1912 as a lecturer on landscape architecture.

Although the name of Lowell did not appear on the roster of incorporators associated with William Barton Rogers in the fateful spring of 1861, that oversight was soon remedied. On May 6, 1862 at the first meeting of the Massachusetts Institute of Technology, John Amory Lowell (of the eighth generation of Percivale Lowle, and son of John Lowell, "The Rebel" who founded the Lowell Institute) was elected to life trusteeship and also as one of the four vice presidents. He continued as vice president of M.I.T. until 1870 when that office was suspended until the election of Vannevar Bush, '16, in 1932.

In 1873, eight years before the death of John Amory Lowell, his son Augustus also was elected a member of the Corporation on which he was to serve for more than a quarter of a century, and serving so nobly that in 1916, when the new Technology was dedicated in Cambridge, his name, and that of Coleman (*Continued on page 182*)



Graceful curves are left in the snow during a downhill ski race at Adelboden in the Bernese Oberland, Switzerland.

Photo by A. Kloppenstein

Orient Mails "Via Pacific"

Monster American Side-Wheelers, the Largest Wooden Commercial Steamers Ever Built, Pioneered a 7,500-Mile Artery of Global Trade

By H. E. Lobdell

EIGHTY years ago this January, mail steamship service to the Far East began under the American flag with the sailing of the Pacific Mail Steamship Company's *Colorado* from San Francisco, promptly at noon on New Year's Day of 1867. This three-year-old wooden side-wheeler, 340 feet in length and in tonnage a bit over 3,700, reached Yokohama on the morning of January 24. There she coaled and on the following day resumed her pioneer voyage, arriving at Victoria, Hong Kong, by midnight of January 30.

At Victoria she spent a fortnight during which, according to a newspaper account appearing after her return to San Francisco in the local *Alta*, there was an "excursion around Hong Kong island with about 1,000 invited guests . . . 'A rush was made for the dining saloon, and the clatter of knives and forks, and the flying of champagne corks could be heard in every direction. There was just as much of everything as was wanted, and everything being free, they just went into the good things like old soldiers.' The band of the Twentieth Regiment was aboard, a quadrille was made up, and dancing went forward in spirited fashion until the ship returned to anchor" — all of which contributed to the happy result that *Colorado* made a favorable impression on the British in Hong Kong, and sailed eastbound with a good passenger list and far more freight than had been anticipated. Leaving Victoria February 17, she coaled again at Yokohama February 25–27, and docked at San Francisco at 9 A.M. on March 20.

Colorado's pioneer voyage, which had been budgeted to operate at a loss, actually yielded a profit of some $11,000, much to the astonishment of Pacific Mail's officials. Throughout 1867 and up to September 1868, service was regularly maintained at six-week intervals; and then, when *Colorado* had been supplemented by *Great Republic*, *China*, and *Japan* — three of the four enormous wooden paddle-steamers especially designed and built for the San Francisco-Hong Kong run — monthly departures in each direction became effective.

To American interests engaged in the ever-expanding potentialities for commerce with eastern Asia during the period immediately following the close of the Civil War, the advent of this new and dependable means of communication "via Pacific" with correspondents in the Far East was indeed a boon, and its influence was soon reflected statistically. When President Lincoln, less than two months before he was assassinated, signed the Act of February 17, 1865 authorizing the "Establishment of Mail-Steamship Service between the United States and China," our Far Eastern trade was declining and passing into foreign hands. By 1869, however, our total exports to Japan and China were over half again as much as they had been in 1866, and our imports therefrom amounted to one-third more. In dollar volume American trade with eastern Asia had risen to $32,786,231, an increase of 44 per cent in three years.

One very tangible factor in causing this striking reversal of trend between 1866 and 1869 was the opportunity afforded American merchants to communicate postally via Pacific less expensively and more expeditiously with their agents in Yokohama, Hong Kong, and the open Treaty Ports of China — and especially with their agents in Shanghai, between which rising commercial metropolis of north China and Yokohama the Pacific Mail instituted a branch service to connect with the arrival and departures of the liners plying the San Francisco-Yokohama-

S.S. **City of Peking** *and S.S.* **City of Tokio,** ***5,500-ton iron screw liners, built for Pacific Mail Steamship Co. by John Roach and Sons. Entered Transpacific service in 1875, to replace the earlier wooden side-wheelers.*** *(Length 423 feet; breadth, 48 feet; depth, 38 feet.)*

Hong Kong to Boston in 1868, Transpacific per fourth eastbound voyage of Colorado *— to San Francisco, and thence to eastern seaboard via Panama.*

Hong Kong main route. Previously American merchants had suffered a definite disadvantage compared with their European competitors, since the only regularly scheduled means by which their letters could be exchanged with China or Japan was by the governmentally subsidized mail-packets of the British Peninsular and Oriental Steam Navigation Company or the French *Compagnie des Messageries Impériales*, whose Far Eastern operations dated from 1845 and 1862, respectively.

To use either of these British or French postal services most favorably an American merchant was obliged to send his letter trans-Atlantic to connect with the scheduled departure of a steamer from Marseilles for Alexandria, from which latter port mails were conveyed overland across Egypt to Suez, thence down the Red Sea and eastward to Ceylon, Singapore, and eventually to their destinations at the ports of eastern Asia. Not only were all postal charges via Suez high (and American correspondence of course required additional franking to cover the trans-Atlantic passage), but it took approximately two months for a letter sent by this route from New York to reach Hong Kong, and 10 days or a fortnight more for it to reach Shanghai or Yokohama. Moreover, an answer sent to the United States westward over this route cost 54 cents per half ounce from Hong Kong, and by the time it reached New York, Boston, or Philadelphia any news conveyed as to the latest "prices-current" on the China coast was already common knowledge eight days earlier in London or Paris. American merchants located on the Pacific slope were, of course, under an even greater handicap, and as a practical matter their urgent correspondence transmitted via Suez had to be dealt with between California and the East by using the relatively expensive telegraph which had become available trans-continentally in October, 1861.

With the opening of mail service via Pacific in 1867, a half-ounce letter could be sent from Hong Kong to any part of the United States for only eight cents. (In the opposite direction the rate was 10 cents.) Such a letter would reach San Francisco within a month, and even if directed to a point on the eastern seaboard, which meant that it would be forwarded roundabout by way of the Isthmus of Panama, it would arrive in New York as quickly as if it had been sent westward from Hong Kong via Suez. By June, 1869, however, mails began to move trans-continentally across the United States by rail and the time requirement between San Francisco and New York was cut to less than eight days. This meant that the mail-transit time from Hong Kong to New York via Pacific approximated five weeks, which was quicker (as well as cheaper) than if a letter were sent via Suez from Hong Kong to London and its contents were cabled

Shanghai to Iowa in 1867, by U. S. Post Transpacific — from Yokohama per maiden eastbound voyage of China *to San Francisco and thence to eastern seaboard "via Panama."*

Shanghai to New York in 1870 by U. S. Post Transpacific — per Golden Age *of P. M. S. S. Co. to Yokohama, thence by main-line steamer of Pacific Mail to San Francisco, and "via overland" by rail to New York.*

onward to New York by the "Atlantic Telegraph," which had come into operation at about the time the Pacific Mail's steamships began to ply regularly to Japan and China.

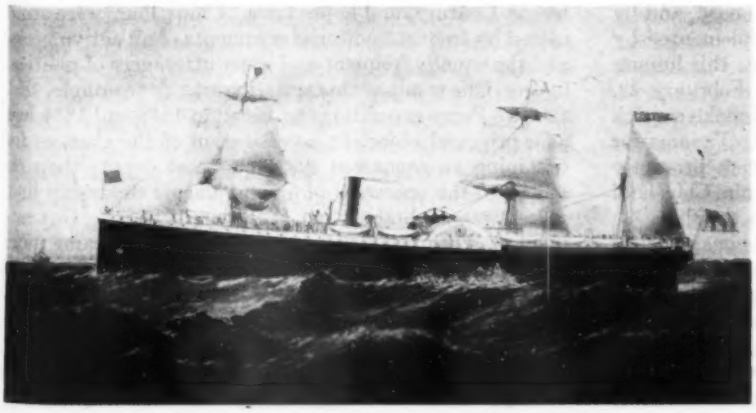
Historical Prelude to Mail Steamship Service Via Pacific

Official thoughts about a trans-Pacific steamer service are recorded as early as 1848, for in May of that year T. Butler King, on behalf of the House Committee on Naval Affairs, recommended early consideration of steam navigation to the Sandwich Islands and China. Also Robert J. Walker, Secretary of the Treasury, in his annual report rendered the following December, blessed the idea as follows:

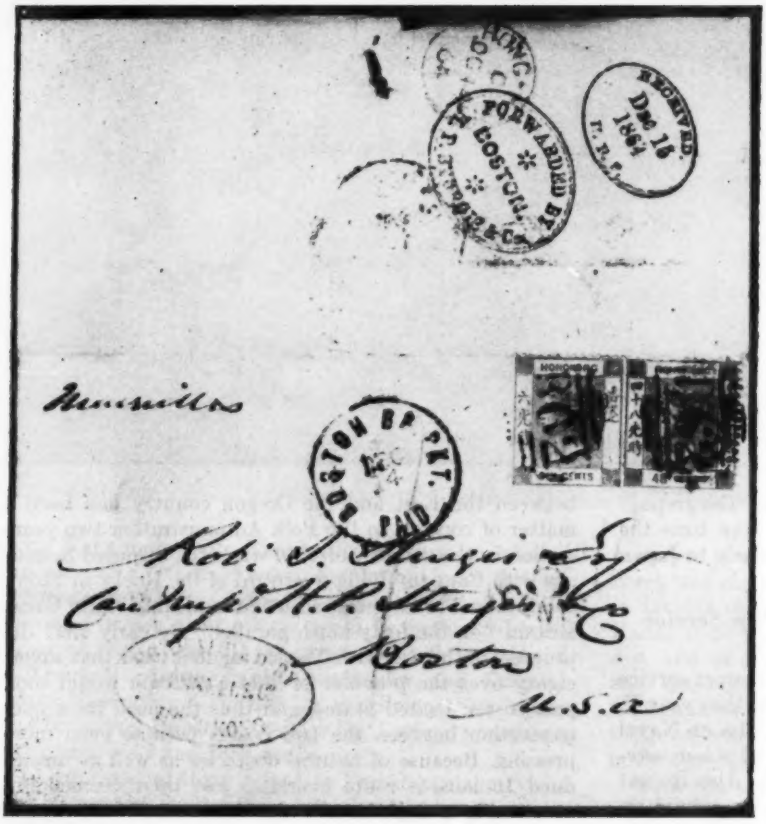
> This tranquil ocean, as indicated by its name more subject to calms, is better adapted to steam than the more boisterous Atlantic, and with less danger of injury to the machinery. The calms of the Pacific, so often retarding the sailing vessel, make shorter and safer the voyage of the steamship, whilst at other periods the trade winds blowing for months continuously in one direction, not affecting the course of the steamer, but forcing sailing vessels so many thousand miles out of their way, render steam necessary to the profitable navigation of that ocean. For all these causes, the Pacific must become the principal theatre of the peaceful triumphs of the great expansive power of steam, and we must extend its use there, under our own flag, if we would desire to contend successfully for the trade and specie of Asia and western America.

Creation of a regular and dependable postal service between the East and the Oregon country had been a matter of concern to the Polk Administration two years earlier, in the summer of 1846 when the disputed boundary with Canada "lying westward of the Rocky or Stony Mountains" was being adjusted amicably with Great Britain "on the forty-ninth parallel." By early 1847 the progress of the war with Mexico made it clear that sovereignty over the province of *Alta California* would soon pass to the United States, and thus the need for a mail connection between the two coasts became even more pressing. Because of natural obstacles as well as unsubdued Indians, a route overland was then deemed impracticable and the water route via Panama was chosen. Under authority of an Act of March 3, 1847 — sometimes called the Mail Steamer Bill — the Secretary of the Navy, who had to approve the designs of merchant vessels built to carry mail under government subsidies in order that they might be useful in time of war as naval auxiliaries, let two contracts for the "Panama Route." That for the Atlantic portion was assigned soon to a group who incorporated under the laws of New York as the United States Mail Steamship Company in March, 1848. The Pacific portion, from Panama to San Francisco, was undertaken by William Henry Aspinwall, Gardiner Greene Howland, Henry Chauncey, and Edwin Bartlett, who also obtained a New York charter, on April 12, 1848 — as the Pacific Mail Steamship Company.

Gold was discovered in California before these charters were granted — in the tail-race of the sawmill of John



S.S. China, *3,826-ton wooden side-wheeler, built for Pacific Mail Steamship Co. by William Henry Webb of New York. Launched December 8, 1866, as* Celestial Empire; *cleared from New York July 1, 1867; entered Transpacific service as* China *from San Francisco for Yokohama and Hong Kong, October 14, 1867. Sold by the Pacific Mail in 1883, and broken up in 1886. (Length, overall, 370 feet; extreme beam, 49 feet 10 inches; load draft 20 feet 4½ inches.)*



Hong Kong to Boston in 1864, by British Post via Marseilles — to Suez by the P. and O. S. N. Co., overland across Egypt, from Alexandria by the P. and O. S. N. Co. to Marseilles, overland across France and Transatlantic by British Packet — bearing 54 cents of Hong Kong adhesives.

Augustus Sutter on the south fork of the American river, on January 24, 1848 — but official confirmation of its discovery reached the East only at the time the 1,058-ton *California*, $200,000 pioneer of the Pacific Mail's fleet, put to sea from New York on October 6th. She was bound via the Straits of Magellan, through which she was the third steamship to pass, to take her station on the run between the Isthmus and San Francisco, and by the time she came to anchor off the city of Panama, on January 17, 1849, the gold rush was on full tilt.

At Panama *California* had expected to pick up some passengers for San Francisco, brought to Chagres on the Atlantic side of the Isthmus by vessels leaving New York later than the departure of *California;* but at Panama there were waiting nearly three times as many as her designed capacity of 250. Somehow, 356 passengers in addition to her crew of 36 were squeezed aboard, and by exhausting the last of her coal supply, supplemented by burning some of her woodwork and fittings, this human cargo was deposited at San Francisco on February 28. It had been expected that *California* would make a quick turn-round at San Francisco and go back to Panama for more prospectors, but her crew and officers promptly deserted for the mines, leaving only Captain Cleveland Forbes and a lone engine-room boy to man the ship.

When *California's* sisters, *Oregon* and *Panama*, reached San Francisco on April 1 and June 4, respectively, they were likewise crowded beyond capacity and speculators had run the price of single steerage tickets from Panama to the Golden Gate as high as $1,000, compared with the established fares of $250 for first-cabin, $200 for the lower cabin, and $100 for steerage. *Oregon's* captain took the precaution of anchoring at San Francisco under the guns of a warship in the harbor, and kept his crew in irons until they begrudgingly submitted to accept a tenfold wage increase. Thus, *Oregon* was the first ship to depart with the eastbound mail on April 12.

The Pacific Mail's prosperity during *California's* lush 1850's kept pace with the mounting national importance of the region it served. Competitive shipping interests, which endeavored to cut-in on the highly profitable San Francisco-Panama traffic, were successfully overcome; and the best of the several overland stage mail-routes which had come into being by 1858, one on a weekly basis, took longer between Missouri and California than the four week average by the Panama route between New York and San Francisco. Confidence as to the future was thus the spirit of the times in the fifth decade of the Nineteenth Century, and hopes for a "China line" were stimulated by frequent editorial comments of an active press, and the equally frequent and eager utterances of political figures. One result of this agitation was, for example, that the two Perry expeditions to Japan in 1853 and 1854 had as a principal objective investigation of the chances for obtaining an organized system of coal depots then essential to the operation of a trans-Pacific steamship line.

In 1860, with the Civil War imminent, the Government at Washington, very understandably, became more immediately concerned with matters other than the petitions of merchants engaged in trading with the Orient. It was vital to speed up communication between the two coasts of the country, and in April the historic Pony Express began to provide at first weekly, and later semi-weekly, transit of letters from (*Continued on page 168*)

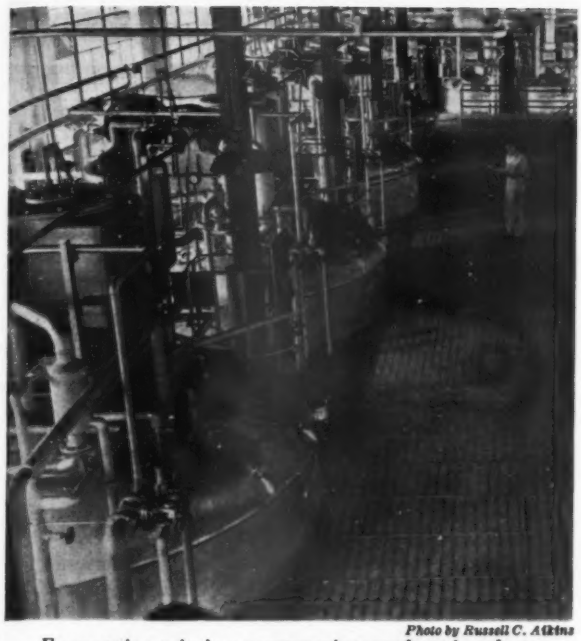


Photo by Russell C. Atkins

Fermentation units in a streptomycin manufacturing plant.

Penicillin and Streptomycin

Supplement Each Other in Safeguarding Man's Health

By Rudolf E. Gruber

IN ITS September 16, 1946, issue *Time* magazine heralded the fact that another antibiotic had come of age with these words: "The wonder drug, streptomycin, was at last ready for general distribution among 1,600 U. S. hospitals. Last week the Civilian Production Administration, the drug's custodian, announced that current production . . . would meet all demand — except for treatment of tuberculosis." Only two and a half years earlier, on May 1, 1944, a similar announcement by the War Production Board recorded the fact that war-born penicillin had reached production levels which justified its release for limited civilian use through distribution by approximately 1,000 depot hospitals.

In an earlier article on the history and development of penicillin* the prediction was made that it was possible that a whole new group of substances, similar to this most powerful of all known chemotherapeutic agents, would be made available. This prediction has indeed come true, but not quite in the manner expected. It was thought that the knowledge of the chemistry of penicillin might either lead to its synthesis or that it would enable organic chemists to develop other compounds which were structurally similar to, and equally as effective as, penicillin, but perhaps easier to use. Chemists had come to such expectation on the basis of previous experience with some of the vitamins, where synthetic production soon followed upon isolation of the pure vitamins from natural sources, as soon as the molecular structure was known. During World War II, the study of the chemical phase of the penicillin problem was undertaken by teams of eminent organic chemists in universities, and in governmental and industrial laboratories in the United States, Great Britain, and Canada. The results of this wartime co-operative research are now being made public; so far there seems to be no indication that synthesis will replace the natural, *i.e.*, microbiological, production of penicillin.

* The Technology Review, March, 1944.

The chemical research program has resulted in great benefits to the effectiveness of penicillin production, nevertheless. Advanced knowledge of penicillin's chemical structure has disclosed the fact that clinical penicillin is not a single substance, but somewhat like the vitamin B complex, consists of a number of components, closely related in composition and action, yet having distinct chemical, as well as biologic, characteristics. Four of these penicillin factors are at present identified and are designated as penicillins *G*, *F*, *K*, and *X*, respectively. Penicillin *G*, a pure crystalline substance, appears to be the most desirable member of the group, combining ease of toleration and clinical effectiveness with enhanced heat stability. Crystalline penicillin *G* is the official reference standard for the assay of clinical penicillin.

Penicillin Production

The contributions of the microbiologists to the phenomenal advances in both improvement of quality and increase in production of penicillin have been manifold. New strains of *Penicillium* have increased the yield of penicillin in the fermentation broth. Some of the new strains have been isolated from nature while others, like the famous X-1612 and Q-176, have been obtained as mutations from previously known organisms by means of x-rays. Total monthly penicillin production capacity in the United States has exceeded three trillion (3,000 billion) Oxford units, and the potency and purity of the final product have been constantly improved. The latest developments are the pure crystalline forms previously mentioned. The price of the once rare drug has rapidly decreased as penicillin went into mass production, and as manufacturing economies and higher yields have been achieved. There is no longer any economic bar to the use of penicillin in any bacterial infection in which the drug is indicated. Medical knowledge of the therapeutic value of penicillin has increased considerably, and, through the experience gained in tremendous war use, has become so precise that the outcome of penicillin treatment can be predicted with remarkable accuracy.

The production miracles accomplished by America's penicillin pioneers made it possible to supply a tremendous foreign demand over and above military and civilian needs at home. Only recently, Great Britain, the homeland of the discoverer of penicillin, saw the completion of huge

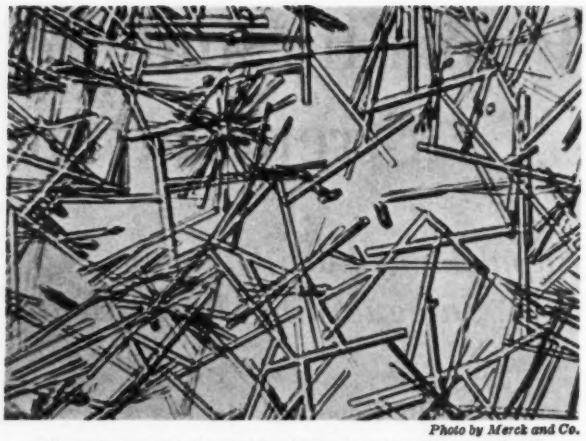
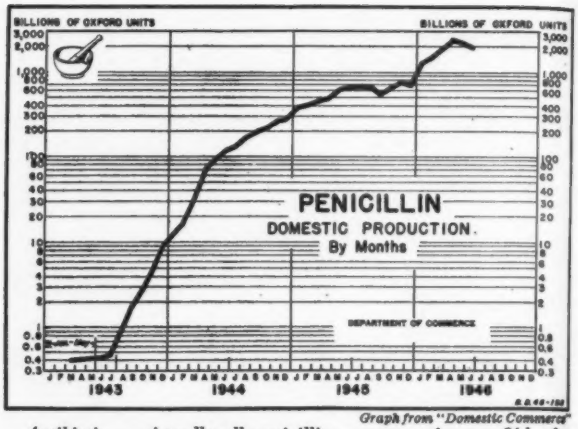


Photo by Merck and Co.

Microphotograph of crystals of streptomycin calcium chloride.



Graph from "Domestic Commerce"

Antibiotics — virtually all penicillin — account for one fifth of pharmaceutical exports for 1946.

production facilities, largely employing American knowledge and techniques. Canada is already self-sufficient through Dominion production. With American aid, war-ravaged France will soon be able to take care of a large part of its requirements through domestic production. It is, perhaps, not generally known that scientists at the Pasteur Institute in Paris had experimented with penicillin during World War II, and hid their work successfully from the prying eyes of the German occupational authorities. As a result of this covert research, a small pilot plant was placed in operation in Paris immediately after the liberation of the city!

High honors have been bestowed deservedly on the British scientists responsible for penicillin's discovery. Both Dr. Alexander Fleming and Dr. Howard Walter Florey were elevated to knighthood by a grateful Britain. With their chemical associate, Dr. Ernest Boris Chain, they received the coveted Nobel Prize in 1945. American penicillin manufacturers expressed their appreciation in a substantial manner by presenting to Sir Alexander Fleming, in the fall of 1945, a trust fund of $100,000 for financing research work to be conducted under his direction at St. Mary's Hospital Medical School at the University of London. The University of Pennsylvania was named administrator of the Fleming Fund, in tribute to Dr. Alfred N. Richards, Vice-president of the University, who, as chairman of the Committee on Medical Research of the Office of Scientific Research and Development (of which Dr. Vannevar Bush, '16, is Director), first supported and encouraged penicillin studies in this country, with immeasurable benefit to the health of our Armed Forces and civilian population.

Origin of Streptomycin

With the recognition of penicillin's amazing clinical value, research on the production of other antibacterial substances derived from the products of metabolism of molds and fungi proceeded apace. Literally, tens of thousands of molds and similar microbial organisms were tested for the antibiotic properties of their metabolites. The most outstanding advance in this field is streptomycin, an antibiotic obtained from the metabolism of a species of myces *Streptomyces griseus*.

Dr. Selman A. Waksman, Russian-born microbiologist at the New Jersey Agricultural Experiment Station, Rutgers University, discovered streptomycin as the result of tests on the antibacterial activity of metabolic substrates of an innumerable number of soil organisms — molds and fungi.

The search for new antibiotics is a highly complex undertaking, as may be appreciated from an outline of the process. The isolation of antagonistic organisms, obtained from the microbiologic population of the soil, is carried out by plating soil on agar media containing washed, living cells of bacteria, and isolating the antagonistic organisms from the plates. The active antibiotic is isolated from the growing medium and then is concentrated and purified. The selection of a preferred antibiotic is largely governed by its toxicity to animals, its activity in the animal body, and its influence upon particular disease-producing bacteria; in other words, by its specific bacteriologic "spectrum." This activity is measured at various dilutions against a whole range of test organisms (bacteria) which are roughly designated as either Gram-positive or Gram-negative.†

Earlier experiments by Waksman's group had produced a mold-metabolite, streptothricin, obtained from *Actinomyces lavendulae*, which showed marked activity against Gram-negative bacteria, but proved too toxic for *in vivo* use. *Streptomyces griseus*, however, another organism of similar type, which is found in heavily manured field soil and belongs to the natural order known as *Actinomycetes*, proved equally effective in *in vitro* tests, and was shown by pharmacologists H. J. Robinson and his associates of the Merck Institute for Therapeutic Research to have low toxicity, *i.e.*, a favorable therapeutic index. At Waksman's suggestion, W. H. Feldman, H. C. Hinshaw, and D. H. Heilman of the Mayo Clinic initiated experiments on experimental tuberculosis in guinea pigs, which have since been translated into the field of human trials. The results of these investigations, while eagerly awaited, cannot be fully evaluated until treatment over long periods, involving huge quantities of the now still rather rare drug, has been carried out. Present observations indicate promise of at least arresting the disease in certain forms.

The usual method of administering streptomycin is by intramuscular or subcutaneous injection, but the drug lends itself to oral administra- (*Continued on page 184*)

† Gram-positive or Gram-negative bacteria are so called according to whether they react positively or negatively to a staining procedure devised by the Danish physician, Hans Christian Gram.

Vacuum in the Home

Based on the Nineteenth Century Carpet Cleaner and Street Sweeper, Today's Portable Household Vacuum Cleaner Awaited the Electric Motor for Its Widespread Popularity

By Sigfried Giedion

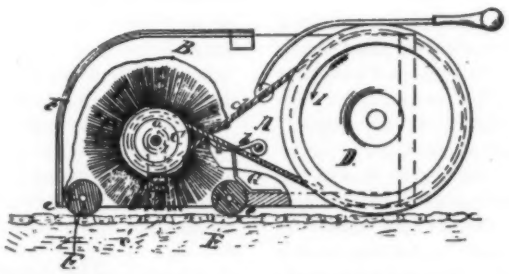
THE term "vacuum cleaner" did not come into use before the beginning of the Twentieth Century and probably not before 1903.[1] During the Nineteenth Century the only term in use was "carpet-sweepers." At the turn of the century heterogeneously named firms appeared in America, claiming to have solved the problems of mechanical cleaning by air suction. After the medium used, one enterprise called itself the Air Cleaning Company. Another's title, Sanitary Devices Company, stressed the elimination of flying dust and the hygienic aspect. Finally, a firm which acquired all the then basic patents,[2] took the name that was later to stand for the whole category, Vacuum Cleaner Company.

Toward the end of the 1850's a number of proposals were made to relieve backbending in carpet cleaning by means of devices to be rolled over the carpet at the end of a handle. The five carpet-sweeping patents granted in 1858 and the nine in 1859 laid down the basic types of mechanism. The solutions center around the idea that a cylindrical revolving brush [3] caused to turn within a small chassis, mounted on wheels or rollers, brushes dirt from the carpet. Neither the drive nor the form of the device have undergone change of principle since the 1850's. [4]

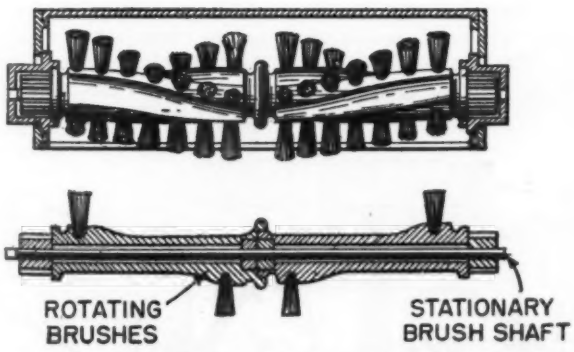
Revolving brushes were first used to clean the streets. Statements in the specialized literature to the effect that the street-sweeper with revolving brushes appeared almost at the same time as "its counterpart, the carpet-sweeper" should be discounted. [5] Indeed the modern street sweeping-machine was invented by the English tool designer, Joseph Whitworth, as early as the 1840's.[6] Its forerunners of the 1820's [7] are extremely primitive. In one of these early examples, the brooms are mounted between two carrying wheels somewhat like the paddles of the water wheel.

But Joseph Whitworth's apparatus represented an example of precision machinery. He used an endless chain of brooms, driven by the axle of the cart. A master hand is seen in the way in which he broke with tradition to form a chain of open and closed links, the open links of which carry the brooms. Carried on the endless chain, the brushes raise the dirt up the inclined carrier plate and dump it into the container. Whitworth's street-sweeper, the first to perform the task mechanically on a broad scale, reveals in all its details the touch of the engineer who by the middle of the Nineteenth Century had brought machine building to a high level of precision.

It was no chance event that the first vacuum cleaner based on suction



The origin of the vacuum cleaner may be traced to the development of street sweepers and carpet cleaners almost 90 years ago. A basic concept of early devices for cleaning carpets is the rotating brush, actuated as the mechanical sweeper was rolled over the carpet by hand, and described in a patent issued to H. Davis on May 24, 1859.



Front view (above) and section (below) showing the manner in which the brushes were arranged in the mechanical carpet sweeper patented in 1859.

[1] Quoting from the Westminster *Gazette* of May 30, 1903, the *Oxford Dictionary* shows how unfamiliar was the idea of cleaning by a void: "There is a machine at work, called the vacuum cleaner." The French speak at that time of a "*nettoyage sanitaire par le vide.*" (*La Nature*, Paris, 1903, p. 376.)

[2] David T. Kenney, U. S. Patent 739263, September 15, 1903, and U. S. Patent 781532, May 28, 1904. Neither of these patents mention a vacuum cleaner; they speak of an "apparatus for removing dust."

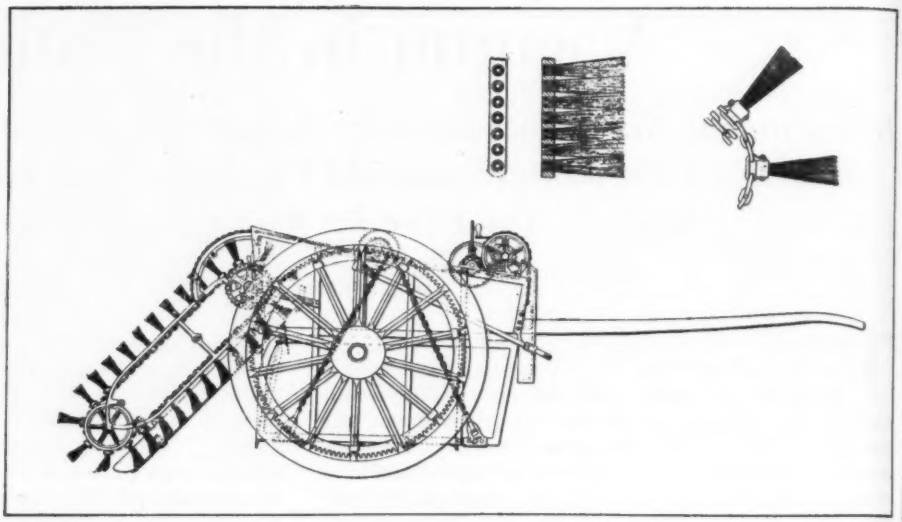
[3] The first patent for mechanical carpet-cleaners, U. S. Patent 21233, August 17, 1858, is based on "a revolving brush connected with driving wheels." The rotary brush first appeared in the street-cleaning machines in 1840. The second, U. S. Patent 21451, September 7, 1858, represents a "combination of a brush with a traction roller."

[4] Cf. U. S. Patent 24103, May 24, 1859.

[5] M. S. Cooley, *Vacuum Cleaning Systems.* (New York, Heating and Ventilating Magazine Co., 1913, p. 3.)

[6] There are two patents. The first is the British Patent 8475 dated April 15, 1840, and entitled "Machinery for Cleaning and Repairing Roads and Ways;" the second, British Patent 9433 of August 2, 1842, was described as "Apparatus for Cleaning Roads." This is also the first American patent (U. S. Patent 3124, June 1, 1843) for street cleaning machinery. The Patent of 1840 includes, among other features, an early (perhaps the first) use of the large rotary brush which Whitworth calls a circular broom It was driven by a crossed sprocket chain.

[7] British Patent 5275, November 1, 1825.



In apparatus devised by Joseph Whitworth of England, the brooms for sweeping dirt from streets were carried on an endless chain to which they were affixed in rows by open links. Dirt was swept into an inclined container and deposited into a receptacle.

appeared in 1859. The period before our Civil War was an era in which were proposed many projects (often fantastic ones) exploiting the gases, air-pressure, or partial vacuum. Ideas based on the properties of gases — and ranging from the injection of carbonic acid into dough, to the Bessemer process, in which air was blasted through molten iron — were frequent, and these led to primitive proposals for using air suction to clean carpets. Following by a few months the first mechanical carpet-sweepers using brushes, there appeared a vacuum appliance whose wheels drove a four-bladed fan.[8]

This carpet fan sweeper of 1859, earliest in the long line of pure suction types, aimed at avoiding the "detrimental" effect of rotating brushes. "The carpet sweepers heretofore contrived have operated by means of a cylindrical brush in contact with the surface of the carpet" the inventor states. "My present invention . . . consists in the employment of a revolving fan in lieu of the brush." The fan, consisting of four metal blades carried on a spindle, is highly geared to a wheel which runs over the carpet so that "by the motion of the fan the dust is blown into the pan and the carpet is cleaned even more perfectly than can be effected by a revolving brush." The inventor is careful to stress that the fan is adjusted so as not to come in direct contact with the carpet. Thus the principle of the domestic vacuum cleaner based purely on suction was invented and clearly formulated by 1859.

Also formulated at this time (1860) was the second type of vacuum cleaner, which combined revolving brushes with a continuous draft.[9] The brushes swept the dust into a draft produced by bellows which are driven by a connecting rod attached to the wheels. In describing this device the inventor said: "The nature of my invention consists in drawing fine dust and dirt through the machine by means of a draft of air," and (this suggestion is interesting at so early a date) "forcing the same into water or . . . anything else which will retain the dust."

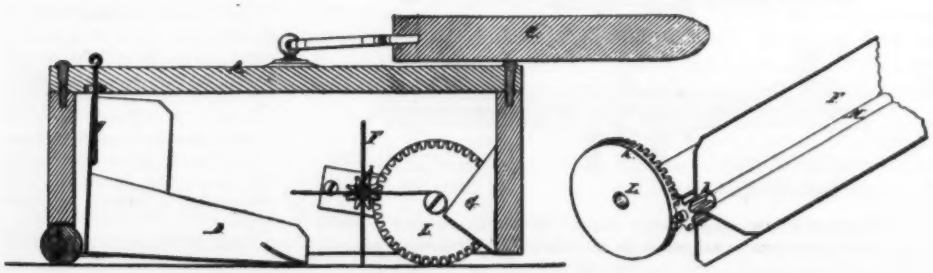
Let us anticipate and glance at what was to follow. These two appliances, that of 1859 and that of 1860, created the basic types, in which were embodied the principles underlying the whole development down to the present day. The bolder principle, that of 1859, which carried the dust away by suction alone, was used on a magnified scale in the fixed American installations after 1900 as well as in the mobile apparatus of England and France. The second type, that of 1860, which used air draft together with rotating brushes was continually improved in its hand-driven form during the Nineteenth Century. Successfully electrified after 1910, it then began to displace the fixed installations.

The Vacuum Cleaner of 1900

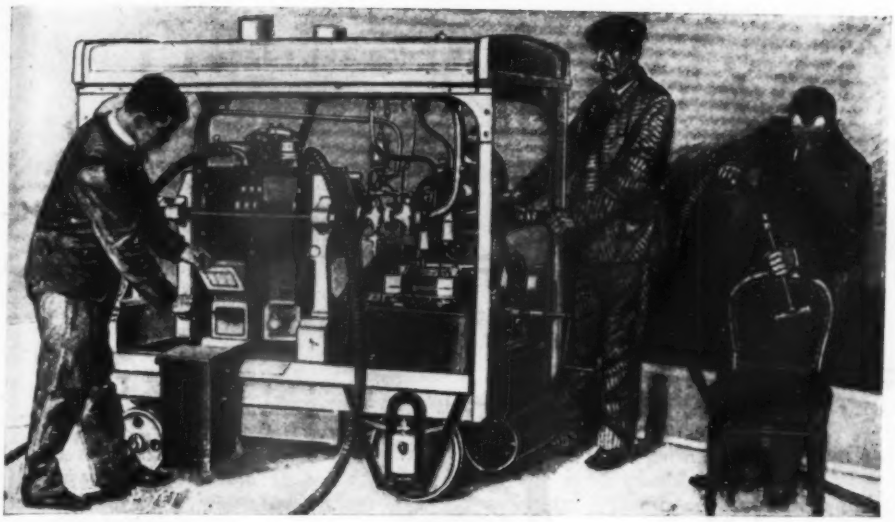
The portable machines were arrived at by a detour. Just as the electric motor had to pass through the gigantic before giving rise to a reliable small motor, so time was needed before the automatically powered vacuum cleaner could be reduced to a tool of convenient size.

As the vacuum cleaner gradually took shape, shortly before 1900, it was a plant of considerable size, suited only to hotels, department stores, or railroad terminals. Three phases can be distinguished before the vacuum cleaner was finally introduced.

[8] Carpet Fan Sweeper, U. S. Patent 22488, January 4, 1859.
[9] U. S. Patent 29077, July 10, 1860.



First attempt to produce a novel cleaning mechanism by partial vacuum and without the aid of brushes made use of a mechanically operated four-blade fan, F, which swept dust into the receptacle, D



Early methods of removing dirt by partial vacuum employed so much equipment that permanent installations were required. Mobile units (of which an example is given by the French installation of 1903, shown at the left), represented a transitional stage between the stationary installations and the portable machines later used in almost every home. Even mobile units were cumbersome affairs, requiring at least two men for their operation.

At first, carpets for cleaning were sent to special centers which were often connected with laundries. There, bulky carpet-beating machines were used, which imitated the human motions of an arm swinging a carpet beater. The first patents appear about 1860.[10] Even after 1900 an English handbook on laundry management surveys the diverse carpet-cleaning systems without any mention of the vacuum cleaner.

Stationary installations within the building formed the second phase. Suction machines in the basements of large establishments were connected by pipelines to outlets throughout the edifice. This explains why vacuum apparatus, made at the turn of the century, might have been made by manufacturers of central heating equipment.[11] America was first to develop installations of this kind.

In the third phase, frequently coexistent with the second, mobile plants on wheels were used. They were moved from house to house by hand, by horse, or by motor. A long, flexible hose was taken into the apartment from the street or court where the pumping unit was parked. At least two men were needed to run this outfit — one to look after the machinery, another to do the cleaning.

[10] Three patents for carpet beating machines were taken out in 1860: U. S. Patents 27730, 28389, and 30590.

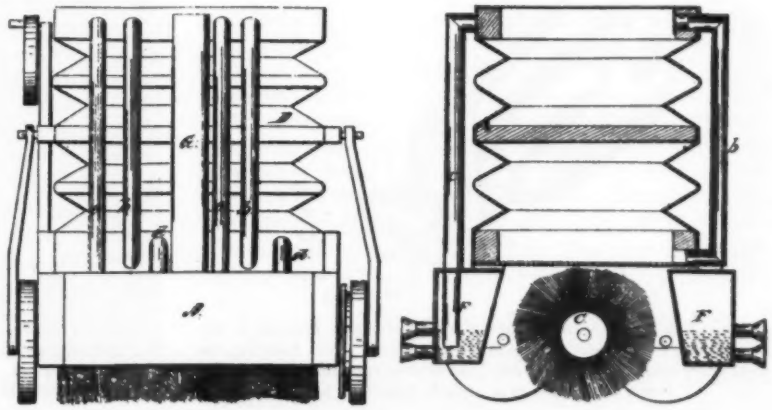
[11] *Laundry Management, a Handbook for Use in Private and Public Laundries*, 4th edition (London, 1902), Chapter 23, Carpet Beating.

Such mobile plants were developed by the French and especially by the English. H. C. Booth, inventor of what the English claim to be the first satisfactory vacuum cleaner, recalls his experiences in the early days, between 1901 and 1903: "It was assumed by the police authorities that the machine had no right to work on a public thoroughfare . . . The Vacuum Cleaner Company was frequently sued for damages for alleged frightening of cab horses in the street."[12] The mobile units were soon reduced in size and the French had moderate sized machines in operation at an early date. They represent a transition between the large stationary plants and the portable appliances for use in the private home.

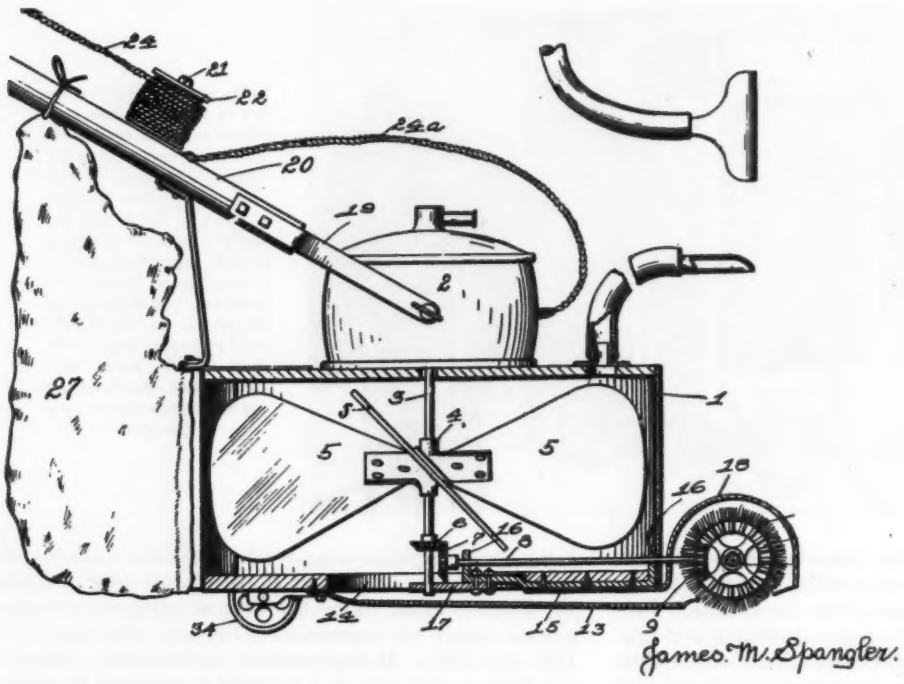
The Question of Origins

There is little certainty as to where the modern type of cleaner, with mechanically created suction, first appeared. About 1900 practice wavered between the use of vacuum and compressed air — between sucking up the dust and blowing it away. The uncertainty occasionally led to a dual method employing a complex mixture of compressed air and vacuum. The forerunner of the vacuum cleaner was the compressed air cleaner used in foundries to blow dust from castings. The first use in cleaning buildings, we are told, "was undoubtedly in the

[12] H. C. Booth, "The Origin of the Vacuum Cleaner" (*Newcomen Society Transactions*, London, 1936), v. 15, p. 93.



A patent of 1860 marks the first use of both rotating brushes and partial vacuum for the removal of dirt from carpets. The partial vacuum was produced by means of a bellows, D, actuated as the mechanism rolled over the carpet. Dirt loosened by the brush, C, was removed by the bellows, D, and deposited through tubes, C, into the water filled collector receptacle, F.



Prototype of the modern vacuum cleaner designs was described in a patent issued to James M. Spangler on June 2, 1908. Motive power for the fan blades, 5, and the rotating brush, 9, was provided by an electrically driven motor, 2. Dirt was deposited in a dust bag, 27, and for convenience of operation, the handle, 20, swivelled from the motor frame. Presumably the device was also intended to clean other household articles, as is indicated by the hose attachment at the uppr right.

form of an open jet for dislodging dust from carvings."[13]

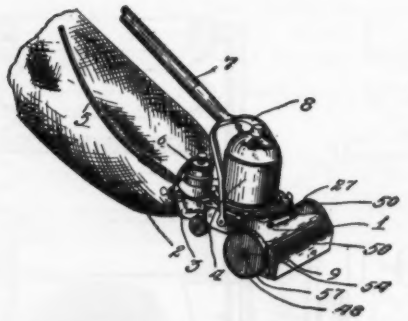
American machines which blew air into the carpet were also demonstrated to the public of other countries. In one of the few references to himself, the Englishman Booth recalls: "My attention was first directed to the mechanical removal of dust from carpets in 1901 through a demonstration of an American machine by its inventor. . . . The machine consisted of a box to which compressed air was supplied; the air was blown down in the carpet from two opposite directions."[14]

As we see, it is hard to ascertain where a satisfactory vacuum cleaner first came into being. The English name H. C. Booth as the inventor of the first machine operating exclusively by suction. His device was patented in 1901[15] and was successfully introduced. Having been stimulated by demonstrations of these American machines which blew air into the carpet, the inventor claims as his own the idea of using suction alone. Booth suggested that the Americans try blowing in the opposite direction, and he made "the experiment of sucking with my mouth against the back of a plush seat in a restaurant on Victoria Street, with the result that I was always choked."[16] There is no doubt but that Booth made his invention independently, not finding out until later that a long series of Nineteenth Century patents had travelled the same path. In his reminiscences upon *The Origin of the Vacuum Cleaner* he gives an interesting enumeration of early patents. Booth's machine of 1901 was a mobile one, mounted on a pushcart.[17]

Shortly after 1900 the French, too, were building compact machines driven by electric motors and mounted on wheelcarts. They claim the invention of a nozzle (which Booth claims as his) for use in cleaning their furniture. Booth claims, moreover, to have been the first to introduce this combination of hose and handle. In France, such machines seem to have been originally used for cleaning theater seats. As much as 217 kilograms (478 pounds) of dust are said to have been removed from the chairs of a theater[18] in a single cleaning operation.

(*Continued on page 176*)

[13] M. S. Cooley, *op. cit.*, p. 4. Again we learn from Joseph H. Young, Vice-president of the Westinghouse Air Brake Company, that when superintendent for the Union Pacific at Salt Lake City 1892–1893, he and David Patterson, master mechanic of the Union Pacific, sought to improve the manner of cleaning the car interiors. They coupled together a number of air-brake pumps in an effort to blow away the dust. When this proved impracticable they worked out a siphon method which sucked air up a hose and blew it out of the window. This was so successful that it was generally adopted by the Union Pacific for the cleaning of coaches and Pullman cars at its various passenger terminals. At the same time they developed a nozzle to spray paint on the outside of freight cars and wooden buildings. Although this procedure was taken over for the painting of ships, a patent application was denied on grounds that the principle conflicted with earlier patents for kindling fires in locomotive fire boxes by blowing oil from a tank by compressed air.



Simplicity and compactness were the improvements brought to his earlier patent by James M. Spangler in August 1915. Entering the mail order catalogs two years later, the electric vacuum appliance becomes established as a popular household tool.

[14] Booth, *op. cit.*, p. 85

[15] British Patent 17433, August 30, 1901.

[16] Booth, *op. cit.*, p. 86.

[17] Illustrations in Booth, *op. cit.*, Plate XI.

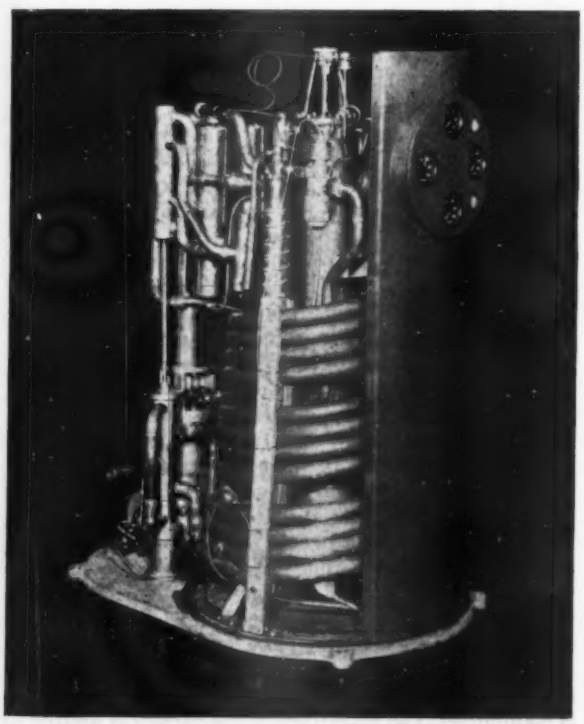
Progress in Low Temperature Refrigeration

Gasoline from Natural Gas Is One By-Product of Low Cost Oxygen Which Is Made Possible by Research in Low Temperature Refrigeration

By S. C. Collins

A LOW pressure oxygen generating system which was initiated and largely developed at the Massachusetts Institute of Technology during the war is finding extensive application in our post-war economy. Installations planned for the immediate future will more than double the production of oxygen in the United States. This phenomenal expansion is the result of the substantial reduction in cost of production which the new equipment has effected. Low-cost oxygen finds new industrial uses which demand quantities of a magnitude unheard of so long as welding, cutting of steel, and breathing were its chief applications.

Since the beginning of the Twentieth Century, the preparation of commercial oxygen from air by distilling liquefied air has passed from the experimental stage to large-scale production, but the equipment for production in use at the present time is substantially identical with that devised by Linde and Claude 40 years ago. Air is compressed (500 to 3,000 pounds per square inch), freed of carbon dioxide and water by treatment with chemicals which unite with or absorb them, cooled to a very low temperature in a counter flow heat exchanger by loss of heat to cool streams of nitrogen and oxygen flowing in the opposite direction, condensed in the base of the rectifying column by the evaporation of liquid oxygen at low pressure and finally resolved into its pure components in the column. The refrigeration required to maintain operating conditions is supplied by the Joule-Thomson effect in the Linde process. In Claude's method, the Joule-Thomson cooling is augmented by allowing the expansion of the compressed air to occur in an engine which performs useful external work.



Photograph of small oxygen generator, a schematic diagram of which is shown on the next page

Since water and carbon dioxide freeze at temperatures far above the boiling point of liquid air, they must be fairly completely removed. Methods other than chemical treatment for purifying air have been tried and have been found unsatisfactory for one reason or another. The most successful was the substitution of two pairs of cold accumulators [1] or regenerators for the counter flow heat exchanger. In the cold accumulators, condensible impurities are frozen out of the air and later carried away by the nitrogen and the oxygen. The oxygen, however, is badly contaminated with air.

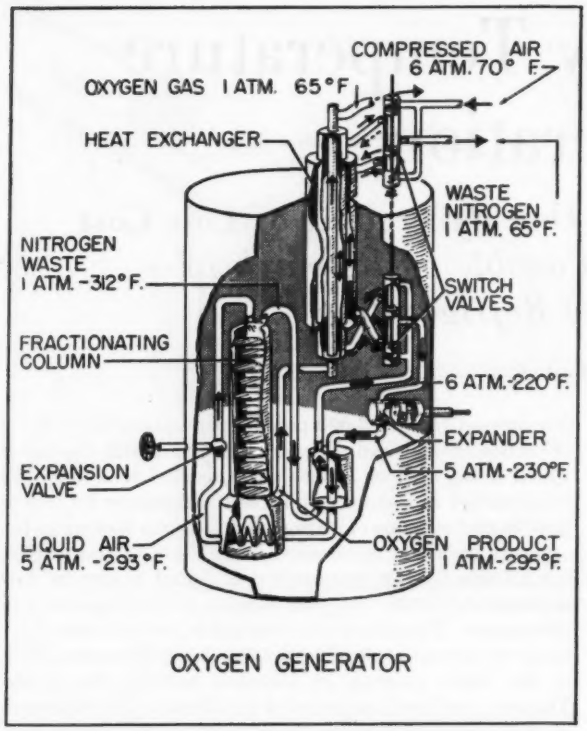
The distinguishing features of the M.I.T. oxygen system are the reversing exchangers [2] which achieve mechanical purification and the highly efficient flexible rod expansion engine [3] which has made practicable operation at 85 to 150 pounds per square inch. Their development was part of an extensive study of oxygen problems sponsored by the National Defense Research Committee and by the Aero Medical Laboratory of Wright Field.

Reversing exchangers completely remove the water and carbon dioxide without impairing the purity of the product. They are also much lighter and less bulky than the accumulators. The exchanger consists of a number of tube assemblies in parallel — each assembly containing three channels; one for compressed air, one for waste nitrogen and one for oxygen. At intervals of about four minutes the compressed air and waste nitrogen channels are interchanged by the automatic action of the switch valves, as shown in the diagram of the oxygen generator. During one half-cycle, impurities freeze out upon the walls

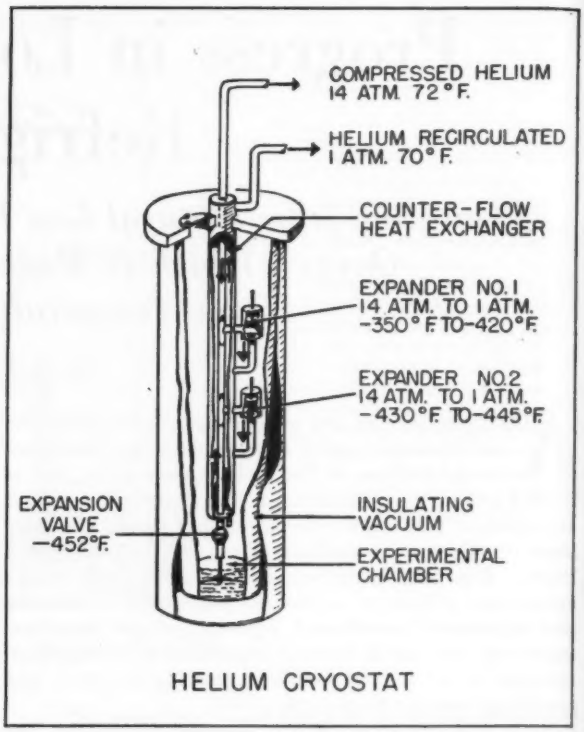
[1] Ruhemann, M., The Separation of Gases (Oxford Press 1940).

[2] Collins, S. C., "Reversing Exchangers for Purifying Air." Scheduled for publication in the December 1946 issue of *Chemical Engineering*.

[3] Collins, S. C., "A Helium Cryostat." Scheduled for publication in the January 1947 issue of *Review of Scientific Instruments*.



OXYGEN GENERATOR



HELIUM CRYOSTAT

of the channel carrying compressed air. During the next half-cycle, waste nitrogen flows in the opposite direction through the particular channel and the impurities evaporate into the nitrogen stream. The heat exchanger may thereby be used indefinitely without clogging.

Improvements in expansion devices for cooling by the performance of external work have been made. Flexible rod expansion engines with nitrided steel pistons and cylinders operating with slight clearances, without piston rings and without lubricant other than gaseous air, have shown unusually high efficiency. Elsewhere turbo-expanders for large installations have been developed.

With the improvements described above, it is possible to operate large plants on raw air at 85 pounds per square inch. The power cost of gaseous oxygen at low pressure is simply the cost of compressing atmospheric air, from which it is made, to 85 pounds per square inch. Operational hazards, a serious matter in all plants of the Linde and Claude types, are substantially reduced in the M.I.T. system. The reversing exchangers are so effective in capturing condensible impurities that hydrocarbons from the lubricating oil used in the compressor do not concentrate in the column. Acetylene and methane, however, must be kept away from the air supply.

Applications in which low-cost oxygen consumption is expected to become important are the production of gasoline from natural gas, blast furnace and other metallurgical operations, and the gasification of low grade fuels.

The Function of Low Temperature Research

Aside from the satisfaction of gaining more knowledge about the behavior of matter in a new environment, definite gains in understanding basic physical principles have been achieved from low temperature research. Extensive measurements of specific heats of a great variety of substances over the attainable temperature range, together with known constants of chemical equilibrium, have provided abundant verification of the principle that the entropy of stable chemical substances may be considered to be zero at the absolute zero of temperature. By measuring specific heats down to very low temperatures, latent heats of fusion, vaporization, and transition, as well as heats of reaction, one can evaluate the entropy of substances at other temperatures. Since the thermodynamic relationship between the equilibrium constant of any chemical reaction, the entropy of substances taking part in the reaction, and the heat of reaction is accurately known, it is possible to determine from calorimetric data alone, the best operating conditions and yield that can be expected.

The mass of data that now exists at low temperatures concerning thermal and electrical conductivities, magnetic susceptibility, and so on, has served to complete our understanding of certain classes of phenomena; it has also created new mysteries which clamor for solution. Notable discoveries are the superconducting state and the abnormalities of liquid helium II, the name applied to liquid helium below the transition temperature of 2.18° K at which the peculiar behavior sets in. Under certain conditions, liquid helium II climbs the wall of its container, goes over the lip and down the outside, and drips from the bottom. It will flow uphill through a capillary or through porous material in the presence of a temperature gradient in the right direction. Many substances lose their electrical resistance at very low temperatures and are said, therefore, to be superconducting. An electric current set up by induction in such a conductor continues to flow as long as the proper temperature level is maintained. The magnitude of the current is limited to fairly small values, however, (*Continued on page 188*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Honors

THE Medal of Freedom, which is awarded by the War Department for exceptionally meritorious achievement during the war, was presented to Dr. Edward L. Moreland, Executive Vice-president of the Institute and Deputy Dean of Engineering, and to Dr. George R. Harrison, Dean of Science on December 3 in a ceremony in Dr. Harrison's office. The medals were presented to Dr. Moreland and Dr. Harrison by Major Douglas McKillop of the Adjutant General's Office.

The citation accompanying the award to Dr. Moreland stated that as Chief of the Scientific and Technical Advisory Committee, General Headquarters, United States Army in the Pacific from August to November, 1945, he "ably organized the facilities, personnel and equipment to handle many scientific and technical problems. With the surrender of Japan, he speedily and efficiently formed a group of specialists to secure data on Japanese technical research facilities and accomplishments before it could be destroyed. Through his skill and ability, Dr. Moreland contributed notably to the preservation of valuable records and information and to the study of Japanese research and developments."

Dr. Harrison's citation stated that "as organizer and Chief of the Southwest Pacific section of the Office of Field Service from March to July 1944, he contributed materially to the application of the weapons of science against the enemy and forces of nature confronting troops in Pacific areas. He served with marked ability in connection with the moisture and fungus proofing of electronic equipment, the modifying of light weight radar equipment for island warfare, the investigation of radio wave propagation characteristics under tropical conditions, and the development of electronic navigational aids, all of which activities were contributions of unusual importance to ultimate victory in the Pacific."

Members of the administrative staff who attended the ceremony included Dean John W. M. Bunker, Dean Thomas K. Sherwood, Dean William W. Wurster, Professor John E. Burchard, Captain William H. Buracker, Colonel Harold R. Jackson and Robert M. Kimball.

Henry H. W. Keith — 1879–1946

PROFESSOR Henry H. W. Keith, who retired as Head of the Department of Naval Architecture and Marine Engineering, on January 1st, 1946, died on December 3rd. He was 67 years old.

Professor Keith's association with the Institute began as a student in 1901, and for five years after his graduation in 1905 he was engaged in research at the United States Experimental Model Basin at the Navy Yard in Washington, where he worked under Rear Admiral David W. Taylor.

His teaching career at the Institute, which began in 1910 when he was appointed instructor in naval architecture, was interrupted at the time of World War I, by active service as lieutenant commander in the Construction Corps of the United States Naval Reserve. At the time of his enlistment he was Assistant Professor of Naval Architecture. Thereafter he served as Associate Professor from 1922 to 1928, becoming a full Professor in 1928. In 1937 he succeeded Professor James R. Jack as head of his department.

Professor Keith was a member of the Society of Naval Architects and Marine Engineers, the American Society of Naval Engineers, the United States Naval Institute, the North East Coast Institution of Engineers and Shipbuilders of England, the Military Order of the World War, the Naval Order of the United States, and Sigma Xi.

Appointment

THE appointment of R. Colin Maclaurin as Personnel Officer of the Institute, has been announced by President Compton.

Son of the late president of the Institute, Dr. Richard C. Maclaurin, and a graduate of Harvard University, Mr. Maclaurin comes to the Institute after serving in the United States Navy for three years as Assistant Industrial Relations Officer at the Boston Navy Yard. Prior to entering the service, he had industrial relations experience at the John P. Squire Company and the Fore River Shipyard.

Annapolis to M.I.T.

VICE Admiral Edward L. Cochrane, Chief of the Material Division of the United States Navy, and former Chief of the Bureau of Ships, has been appointed head of the Department of Naval Architecture and Marine Engineering at M.I.T. and Commander E. C. Holtzworth, U.S.N. has been named Professor of Naval Construction in the same Department, according to announcements recently made by President Compton.

Succeeding the late Professor Henry H. W. Keith, '05, who retired last January after serving 35 years on the Institute's staff and whose death is recorded on this page, Admiral Cochrane will assume his new duties early in 1947. Commander Holtzworth succeeds Professor Charles P. Wheelock who was promoted to the rank of Rear Admiral and named Deputy and Assistant Chief of the Bureau of Ships on November 1.

Chief of the Bureau of Ships from November 1942 until his appointment to the post of Chief of the Material Division, Admiral Cochrane is the son of Brig. Gen. Henry Clay Cochrane of the United States Marine Corps and Elizabeth (Lull) Cochrane. After studying at the University of Pennsylvania from 1909 to 1910, he entered the United States Naval Academy, was graduated with distinction in 1914 as an ensign, and advanced through the grades to his present rank in 1945. He carried on post graduate work at the United States Naval Acad-

emy until 1916, and was then sent to M.I.T. for further advanced work in naval construction for which he was awarded the degree of master of science in 1920. Admiral Cochrane attended the United States War College in 1939.

From 1917 to 1919 he was assigned to the Philadelphia Navy Yard, after which he came to M.I.T. for his graduate work and returned to Philadelphia, where he remained from 1920 to 1924, first in charge of construction of two battle cruisers, and later in charge of repairs. From 1924 to 1929 he was assigned to the Bureau of Construction and Repair of the Navy Department, specializing in submarine and general ship design.

In 1929 Admiral Cochrane was technical advisor to the United States Delegation of the International Conference on the Safety of Life at Sea, which was held in London. He was in charge of design and construction of submarines at the Navy Yard at Portsmouth, N. H., 1929 to 1933, when he was assigned as the Force Constructor on its Staff and was Commander in the Scouting Force of the United States Fleet from 1933 to 1935. From that year until 1939 he was in charge of contract design, and from 1939 to 1940 he served as assistant to the head of the Design Division of the Bureau of Construction and Repair. It was in 1940 that Admiral Cochrane was appointed Naval Attaché at the American Embassy in London and a year later he was assigned to the post of Hull Assistant to the Head of the Design Division of the Bureau of Ships, where he served until his appointment as Chief of the Bureau of Ships in 1942.

Admiral Cochrane was awarded the Mexican Campaign Medal in 1914, the Victory Medal, World War I in 1919, and the American Defense Medal in 1942. He holds the Asiatic-Pacific Campaign Medal, which he was awarded in 1944, and the American Theatre Medal as well as the Victory Medal, World War II, both awarded in 1945. The David W. Taylor Gold Medal for notable achievement in Naval Architecture and Marine Engineering was awarded to Admiral Cochrane in 1945, when he was also made a Knight Commander, Military Division, of the Order of the British Empire. The Navy bestowed upon him in 1946 its Distinguished Service Medal.

Admiral Cochrane holds the honorary degree of Doctor of Laws from Hahnemann Medical College, conferred in 1943, and the honorary degree of Doctor of Engineering which was awarded by Brooklyn Polytechnic Institute in 1946. He is a member of the National Academy of Sciences, the Society of Naval Architecture and Marine Engineering, the American Society of Naval Engineers, the British Institution of Naval Architects, the United States Naval Institute and the American Branch of Newcomen Society of England.

Upon graduation from the U. S. Naval Academy in 1931, Commander Holtzworth was assigned to the light cruiser, USS *Omaha*, for two years before being selected for a course in naval construction at the Institute which he attended from 1933 to 1936, graduating with the degree of Master of Science.

His first assignment to duty as a naval constructor was at the Norfolk Naval Shipyard where, as a superintendent of shipbuilding, he was assigned to experimental work. For two years of his tour of duty at Norfolk he was also on the staff of the University of Virginia conducting an extension course in naval architecture.

Vice Admiral Edward L. Cochrane, Chief of the Material Division of the United States Navy, will assume new duties as head of the Department of Naval Architecture and Marine Engineering

His next assignment, for a period of three years, was the Pearl Harbor Navy Yard where as Design Superintendent he was in charge of the engineering and design organization of the Yard. While in Hawaii he was associated with the University of Hawaii for a period of two years as a lecturer in naval architecture and marine engineering.

Shortly after the start of World War II he was ordered to duty in the Bureau of Ships of the Navy Department in Washington, D. C. He was assigned to the Ship Design Branch of the Bureau as Head of the War Damage Analysis Group. This work has given Commander Holtzworth a most complete picture not only of the effectiveness of the designs of existing men-of-war, but especially qualifies him to help shape the future trends in the design and construction of men-of-war.

Additional duty was assigned to him as technical advisor to the amphibious forces in the Pacific Fleet with reference to the operation and employment of amphibious vessels in assault landings. When the war ended, he was assigned for four months to the Naval Technical Mission to Japan.

Bikini Bound

UNUSUALLY high attendance marked the 252d meeting of the Alumni Council which held its first meeting of the season at 6 P.M. on October 28, in Pritchett Hall of Walker Memorial. As first order of business after the 149 members and guests finished dinner, President Harold Bugbee, '20, introduced new faculty members, class representatives and officers, and Alumni Council representatives and alternates. The minutes of the Council meeting of May 27 were approved. President Bugbee presented a report of the action of the Executive Committee at its special meeting on October 17, in which

Dean H. E. Lobdell, '17 was elevated to the new post of Executive Vice-president of the Alumni Association, an honor to which the Alumni Council gave its unanimous endorsement.

Charles E. Locke, '96, Alumni Secretary, next presented his report which recorded recent actions of the Executive Committee. It was announced that Parke D. Appel, '22 will serve as chairman for Alumni Day which will be Saturday, June 14, 1947. Since the last meeting of the Council at the end of May, visits by members of the Institute's faculty and staff have been made to 10 local M.I.T. clubs. As chairman of the Committee to Nominate Representatives of Local Associations, E. J. Whitcomb, '11, recommended the names of 12 new representatives, and changes in the representation of 10 alternates. Votes of acceptance were given reports presented by Ralph T. Jope, '28, Alumni Treasurer, from H. B. Kane, '24, Alumni Fund Director, and from William L. Campbell, chairman of Alumni Day, June 1946.

President Bugbee then called on Louis B. Baldwin, Jr., '48, who gave a brief account of Freshman Camp activities which were held at the Salvation Army's Camp in Sharon just before the opening of the present school term. Mr. Baldwin reviewed briefly the history of Freshman Camps, included their restricted operation during the war, and gave a résumé of the program at Sharon Camp attended by a record number of students.

The feature of the evening came when President Compton was invited to recount his interesting experiences at Bikini during the summer. Dr. Compton responded by giving a vivid account of his personal experiences of Able Day and Baker Day in the Bikini atom bomb tests and by outlining the destruction which had been wrought. The talk was illustrated with slides as well as with sound pictures in color made by the Navy. The stimulating address and the instructive pictures which were shown led to a long discussion period in which Dr. Compton answered many questions of a most appreciative audience.

Science, Government and Industry

SIR Edward V. Appleton, distinguished scientist of Great Britain and Secretary of the British Department of Scientific and Industrial Research, delivered the inaugural lecture at M.I.T. on the evening of November 19 under the Arthur Dehon Little Memorial Lectureship. The lectureship was established in memory of Arthur D. Little, '85, by the engineering firm which he founded and which bears his name. Its broad purpose is to promote interest and stimulate discussion of the social implications inherent in the development of science through lectures by distinguished contributors to the advancement of science. In keeping with the objectives of the lectureship, Sir Edward spoke on "Science, Government and Industry" in his lecture, open to the public, in Morss Hall, Walker Memorial.

As head of his department, an agency of the British Government, Sir Edward since 1939 has directed research in natural science and its applications to all industrial processes, except in the fields of medicine and agriculture, a task which involved the activities of eight major national laboratories in Great Britain. He is also scientific advisor to the Crown.

Sir Edward V. Appleton, Secretary of the British Department of Scientific and Industrial Research, inaugurated the Arthur Dehon Little lectures with an address on "Science, Government and Industry"

The activities of the Department of Scientific and Industrial research which operate under the Lord President of the Privy Council, began in 1916, and its divisions include building, forest products, fuel, roads, and water pollution, as well as the geographical survey. Its contributions to research and development during the war were particularly notable and its present program includes the major problems of reconstruction and rehabilitation in England.

One of the problems in which Sir Edward is particularly interested and to which much attention is now being given in England is research for small companies which are not large enough to afford laboratories of their own, yet whose progress is to a large degree dependent upon technical investigations leading to improvements in products or the development of entirely new ones.

Sir Edward Appleton was born in England in 1892, and is a graduate of St. John's College, Cambridge, in which he was a distinguished scholar in physics. He served as a captain in the Royal Engineers in the first world war and later as assistant demonstrator in experimental physics at the Cavendish Laboratory, sub-lector at Trinity College, Wheatstone Professor at King's College, University of London, and finally Jacksonian Professor of Natural Philosophy at Cambridge University.

Sir Edward's chief scientific work, for which he earned an international reputation, has been the study of the electrical properties of the upper atmosphere. In 1925 he proved the existence of ionized layers in the upper atmosphere from which radio waves are reflected.

Out of the techniques which he devised for probing the ionosphere came the principle of radio-location. His distinguished scientific discoveries led to an understanding of the principle of propagation of radio waves that

has made it possible to predict the best frequencies for radio transmissions in any part of the world at a given time.

Sir Edward was elected a fellow of the Royal Society at thirty-five and he was awarded the distinguished Hughes Medal of the Society in 1933. In 1929 he was awarded the Morris Liebmann Prize. He is President of the International Scientific Radio Union, and is a past Chairman of the British National Committee for Radiotelegraphy. In 1932 Sir Edward was elected Vice-president of the Institute of Radio Engineers.

Although Sir Edward's work as head of his department is chiefly administrative, he still directs a research team which is carrying out further research on the ionosphere and problems of radio communication.

Arthur Dehon Little, for whom the memorial lectureship was established by the research organization of which he was the leader for so many years, died in 1935. He was internationally known as a pioneer in the application of science to industry. In 1893 he made notable contributions in the field of the chrome tanning process. His studies of the production of artificial silk led to important advances in 1894, and a year later he did significant work on carbon filaments. He was also widely known for the development of water-proof papers, wood waste utilization, methods of producing alcohol, casein products, electrolytic production of chlorine and soda, as well as hypochlorites and chlorates.

Dr. Little was graduated from the Massachusetts Institute of Technology in 1885 and his unfailing interest and training of young men in the advanced study of chemical technology was an important influence in the establishment of the research laboratory of applied chemistry as well as the chemical engineering practice school at M.I.T. He served two terms as president of the American Chemical Society and was president of the American Institute of Chemical Engineering and of the British Society of Chemical Industry. The University of Manchester conferred upon Dr. Little the degree of Doctor of Science in 1929 and the Manchester College of Technology made him an honorary Associate. In 1931 he received the distinguished Perkin Medal award which took cognizance of his influence in establishing chemistry as one of the most important factors in industrial progress.

WMIT, the Beaver Network

BY PAUL ELY, JR., '47

A NEW student activity was launched at 8 P.M. on November 25 when Dr. Karl T. Compton made the inaugural address at the opening of the Institute's first student broadcasting station, WMIT, of the Beaver Network. In commenting on the educational opportunities which the new student activity made possible, President Compton also mentioned some of the difficulties of operating a broadcasting service for students at M.I.T.

With headquarters, studio, and control room in Ware Dormitory, the station will provide regular programs to Technology students during the school year. WMIT operates on the carrier current principle in which the 110-volt power line acts as the medium for distributing the programs as well as the source of electric power. The distance over which signals may be picked up does not extend beyond 20 or 30 feet from the power lines to which the transmitter is coupled. The range is, consequently, so small that no radio license is required and hence this student activity does not come under the jurisdiction of the Federal Communications Commission. At the same time, within the service area of the station which now includes the student dormitories, Walker Memorial and the President's House, programs may be received on any radio broadcast receiver tuned to the station's frequency of 800 kilocycles per second.

WMIT was organized early in October by a group of students headed by Henry Koerner, VI, '47 who now serves as Station Manager, Jack Page, II, '48, Advertising Manager, Paul Ely, Jr., XV, '47, Business Manager, Harold Jacobson, VI, '46, Program Director, Michael Rosar, VI, '47, Technical Manager, Albert J. Davidson, I, '47, and Harold B. Nelson, VI, '48. Together they pooled financial resources and purchased the items necessary to build the transmitter. Grants from the Institute Committee, the Dormitory Committee, and the M.I.T. Administration have made possible the repayment of most of these loans and, by the end of the year, the station's operations should make possible all debt retirement.

The station is operated on a strictly business-like basis, similar to that of commercial broadcasting stations. A constitution was drafted for the student government of the network and was approved by the Institute Committee. Applications for student participation were distributed, and interested students were interviewed and assigned to work in the engineering, program production, advertising, or business departments.

A poll of students living in the dormitories, taken by the business department, showed that the largest percentage of students preferred classical music, with popular music, news of campus activities, lectures, debates and sports receiving support in the order given. In accordance with the results of this poll, the station is operated Monday, Wednesday and Friday evenings between 8 P.M. and midnight.

The station's equipment was built in the Hobby Shop and in the Machine Tool Laboratory by interested students, many of whom had their training in radio during the war or as students in electrical engineering.

Although the coverage at present is limited to students in the dormitories, planned expansion will enable the station to serve the Graduate House, Westgate, and possibly the Dormitory Annex, a temporary structure built for research during the war and now converted into student living quarters. Telephone lines carrying signals will connect the studio with these outlets and a small, remotely controlled transmitter will broadcast these signals in outlying areas. Thus all of the student body living on M.I.T. property on the Cambridge side of the Charles River will be served by WMIT.

Also contemplated is a hook-up with WHCN, the Harvard Crimson Network, in which audio signals will be sent over telephone lines to Harvard where they will be sent over the Crimson's transmitter to both Harvard and Radcliffe students. An interchange of programs between the three colleges will thus be facilitated. It is hoped that other colleges in the Boston area can join this network. WECB at Emerson College plans to join, as does also the Wellesley station. Finally, we look forward to the formation of a Boston collegiate network whose finances and management will be in the hands of representatives from the student networks at each of the colleges in the Boston area. *(Continued on page 168)*

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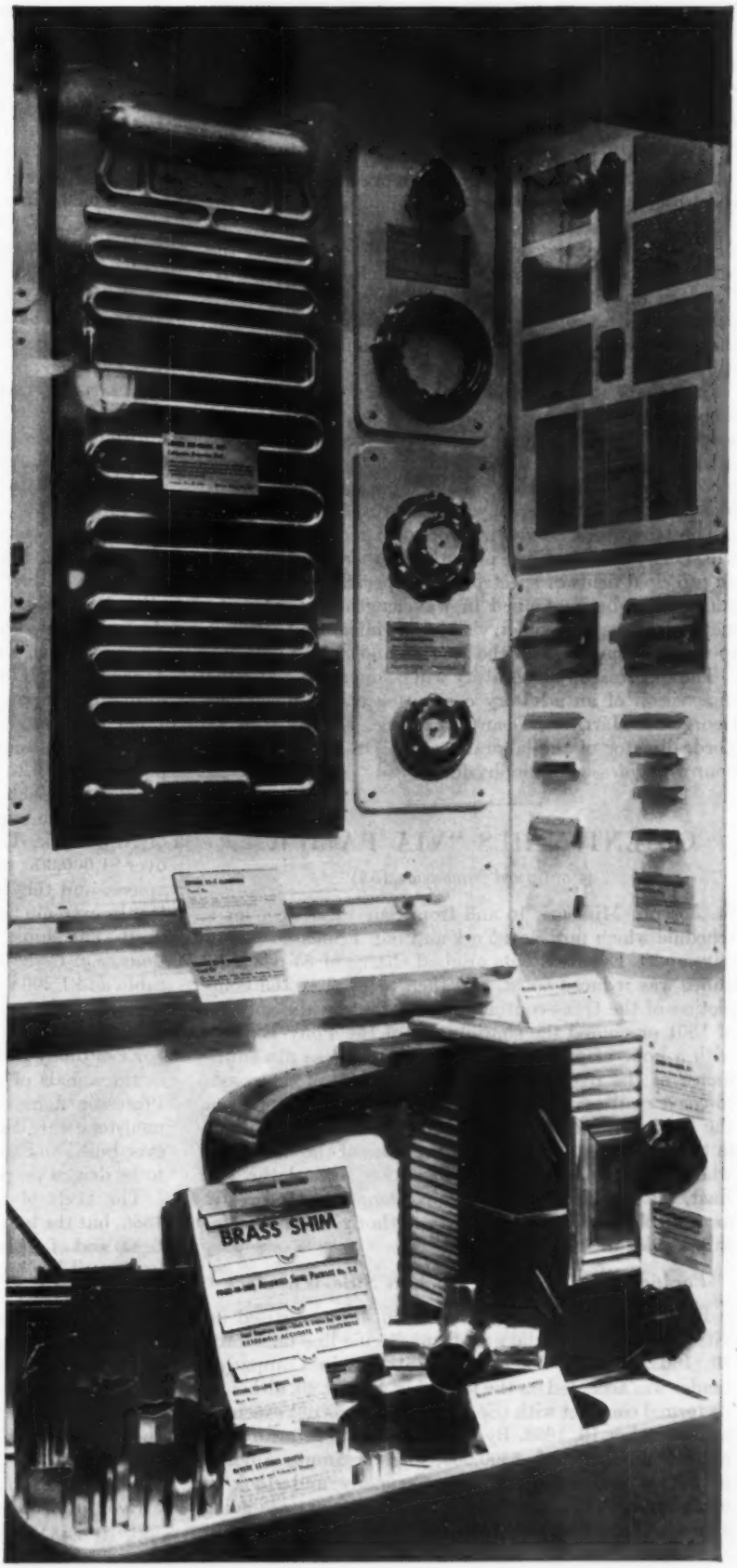

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THE INSTITUTE GAZETTE

(*Continued from page 166*)

Prisms and Gratings

THE M.I.T. program of reconversion from war-time to peace-time projects includes a reorganization of the spectroscopy laboratory and extension of its facilities for co-operative research and graduate instruction. Prior to the war the spectroscopy laboratory was a part of the research laboratory of physics, of which Dr. George R. Harrison was director, and its activities were concerned primarily with problems of interest to physicists. During the war the laboratory was devoted almost entirely to work for the Manhattan District.

In view of the valuable contributions which spectroscopy can make to research in all the basic sciences, the scope of the M.I.T. program in spectroscopy has been enlarged by making the facilities of the spectroscopy laboratory more directly available to research workers in biology, chemistry, geology, metallurgy and physics.

The laboratory is now in process of reconversion and will shortly have facilities in working order for research in all principal fields of spectroscopy. Specific research programs have been planned in wavelength and intensity measurements, ultraviolet, visible, and infrared absorption spectrophotometry, and the Raman and Zeeman effects.

The spectroscopy laboratory will be operated under the supervision of an advisory committee composed of Dr. George R. Harrison, Dean of Science, Dr. Richard C. Lord, director of the laboratory and Dr. John R. Loofbourow, professor of biophysics.

ORIENT MAILS "VIA PACIFIC"

(*Continued from page 154*)

St. Joseph, Missouri, to and from San Francisco, on a schedule which put New York and San Francisco but 12 days apart. Eventually its original charge of $5 per half-ounce was reduced to $2, and then to $1, but the completion of the trans-continental telegraph in the autumn of 1861 precluded the continuance of the Pony Express with a hope of profit. Similarly, the ultimate discontinuance of the overland stage-routes — and of the coast-to-coast mail service via Panama — was forecast when the Union Pacific railway was chartered in 1862. It was in these circumstances that, at the close of the Civil War when Congress again turned attention toward the Far East, the Pacific Mail Steamship Company stood ready as the sole-bidder for the newly authorized mail-steamship service to the Far East.

Pacific Mails' Pioneer Wooden Side-Wheelers

Postmaster General William Dennison advertised inviting proposals for the new trans-Pacific line on March 20, 1865, and the Pacific Mail Steamship Company's tender was accepted on the following August 28, although its formal contract with the government was not executed until October 16, 1866. By this contract, in return for an annual payment of $500,000, the maximum amount permitted under the Act, the Company undertook to establish a ". . . monthly line of first-class sea-going side-wheel steamships of from thirty-five hundred to four thousand tons burden each, government measure and of sufficient number, not less than four, to perform the required monthly service for and during a term of ten years, commencing on or before the first day of January 1867, and from the day the first steamship of the line shall depart with the mails for the Sandwich Islands . . ." to Yokohama, and Hong Kong.

In addition to other liabilities which the Company would incur for non-performance or delays, the contract specified that, ". . . suitable fines shall also be imposed unless the delinquency shall be satisfactorily explained to the Postmaster General, in due time, for failure to take or deliver the mail or any part of it; for suffering it to be wet, injured, lost or destroyed; for carrying it in a place or manner that exposes it to depredation, loss, or injury, by being wet or otherwise; and for setting up, or running, an express to transmit letters or commercial intelligence in advance of the mails; or for transmitting knowingly, or after being informed, any one engaged in transporting letters or mail matter in violation of the laws of the United States. . . ."

To fulfill its obligations the Company ordered four new steamers especially designed for the Far Eastern service: *China* from William Henry Webb of New York (previously the builder of *California*, *Panama*, *Colorado*, and other Pacific Mail liners); and *Great Republic*, *Japan*, and *America* from Henry Steers of Greenpoint, Long Island. Although each of these ships would coal regularly at Yokohama in both directions, the distance between California and Japan made obligatory a bunker capacity of 1,500 tons, in order to supply a 45-ton average daily consumption required to drive the 40-foot diameter paddle-wheels to accomplish an average sea-speed of 9.5 knots. Each ship had 1,500 horsepower vertical walking-beam engines built by the Novelty Iron Works of New York. These steamers, each of which cost just over $1,000,000, measured approximately 4,000 tons gross apiece, and they averaged 380 feet in overall length, 50 feet in extreme beam, and somewhat over 20 feet in load draft. The ships, however, differed in their accommodations, *e.g. Great Republic* had a capacity of 250 in the cabin and 1,200 in the steerage, while *China* was designed to carry 500 first- and second-cabin passengers and 800 in the steerage.

Even today these ships retain a position of significance in the annals of naval architecture for, in the words of Professor John Haskell Kemble, "these Pacific Mail monsters were the largest wooden commercial steamers ever built, and were the last of the great ocean steamers to be driven by paddle-wheels."

The keels of the first pair were laid down early in 1866, but the launchings of the *Great Republic* on November 8 and of *China* (as *Celestial Empire*, which name she bore until her trial trip) on December 8 came too late to permit either vessel being sent around South America in time to inaugurate the new service from San Francisco westbound on the appointed date of January 1, 1867. The distinction of making the pioneer voyage thus fell to *Colorado*, which also completed two further roundtrips before she became a spare ship and was superseded on the regular trans-Pacific schedules by *Great Republic* and *China*.

Service was maintained at six-week intervals until the arrival of *Japan*, originally known as *Niphon* when

(*Continued on page 170*)

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ORIENT MAILS "VIA PACIFIC"

(*Continued from page 168*)

launched by Steers on September 17, 1867. Monthly schedules became effective on August 3, 1868, when *Japan* departed from San Francisco on her maiden voyage. The fourth ship, *America*, was launched July 23, 1868, and, unlike her predecessors, was sent out to the Pacific via the Cape of Good Hope rather than around South America. She reached Hong Kong on August 21, 1869, entered the trans-Pacific mail service from there on September 18, and completed her first eastbound crossing at San Francisco on October 20.

During 1866, in planning for the four new steamers, certain objections arose against the provision in the Act of February 17, 1865, requiring stops at Honolulu on each outward and inward voyage. The principal trouble, in the words of Mr. Dennison's successor, Postmaster General Alexander W. Randall, was that,

> . . . the contractors encountered a practical difficulty arising out of two conflicting conditions: first, the necessity of constructing ships that could make the long voyage of 7,087 miles between San Francisco and Hong Kong, by the route named in the law, with safety and success, as regards the main object for which Congress authorized the establishment of the line; and secondly, the practicability of securing that object, without making the ships so large as to preclude, by their heavy draught, the possibility of entering the harbor of Honolulu, which had a depth of water, under favorable circumstances, of barely 21 feet . . . .
>
> Although the law, and the contract executed in pursuance thereof, name Honolulu as an intermediate port, the fact appears to be established by reliable official information, that the laws which govern the Pacific Ocean, render it unwise, if not incompatible with the complete success of the enterprise, to require the steamships to touch at the Sandwich Islands on their passages between San Francisco, Japan, and China.

Mr. Randall therefore acquiesced in the omission of a call at Honolulu by *Colorado* on its pioneer voyage, and his recommendations to Congress resulted in the Act of February 18, 1867. Under this legislation, Pacific Mail steamers were permitted to ply non-stop between San Francisco and Yokohama, upon the condition, as expressed in an amended contract signed March 20, 1867, that the Company would commence a "branch service from Yokohama to Shanghae and back in connection with the steamship leaving San Francisco on third July, eighteen hundred and sixty-seven."

Prior to the actual institution of this branch service, it was announced in Shanghai that *Colorado* would call there on May 22, 1867, when homeward bound from Hong Kong on her second round trip. This arrangement had to be altered, however, and instead a connection was made with her "off the Saddles" — a small group of islands in the estuary of the Yangtze — by *Yesso*, a British steamer belonging to Dent and Company. But when *Colorado* arrived at Yokohama on July 27, westbound on her third round trip, she was greeted by Pacific Mail's *Costa Rica*, which took off the Shanghai mails and passengers and delivered them at destination on August 3, a day less than one month out of San Francisco.

Both the 1,950-ton *Costa Rica* and the 2,217-ton *New York* had been purchased by the Pacific Mail from Cornelius Vanderbilt after they had seen service between

(*Continued on page 172*)

Cornerstone says "1924" Heating Results say "1946"

Twenty-two years of keeping up-to-date—that's the reason for the heating comfort and economy enjoyed by Trenton Trust Company.

Trenton Trust was founded in 1888—the same year Webster started serving steam-using customers. In 1924 when their present building was built it was provided with a Webster Heating System. Webster Sylphon Traps were installed on the 614 radiators and vacuum assured by a Nash Vacuum Pump.

Thus started a business relationship that has continued for 22 years. Webster worked with the architect and the contractor, Piper Brothers, on the original installation. In 1939 Webster worked with Walter E. Bittner, Trenton contractor, on the extension. At that time, in order to give the entire building full advantage of newer developments, a 4-zone Webster Moderator System with balancing orifices and automatic control-by-the-weather was added.

It takes more than proper selection of equipment to get maximum results in comfort and low-cost in a large heating installation—teamwork to assure proper use is also essential. Throughout the 22-year record of this installation, teamwork has been provided for Trenton Trust by Maurice Neeley, now Superintendent of Maintenance and Operations, and Samuel M. Brooks, Webster Service Engineer. Repairs have been few, but promptly made when needed; maintenance has been regular; pressures have been kept low.

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Maurice Neeley
Supt. Maintenance & Operations for Trenton Trust Company Building, with Trenton Trust since 1924.

S. M. Brooks
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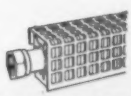


New! Webster Type W I Radiation for installation where floor or wall space is limited.

ORIENT MAILS "VIA PACIFIC"

(*Continued from page 170*)

New York and Aspinwall, on the Atlantic side of the Isthmus of Panama, and both were sent out to the Far East via the Cape of Good Hope. *New York* was assigned regularly to the Shanghai-Yokohama branch line, but also served as a spare steamer for the main line. In April, 1868, she temporarily replaced *Great Republic*, which fractured her starboard paddle-shaft when westbound for Yokohama, at which port she had to lay until *Colorado* could bring out a replacement part from San Francisco. The accident occurred when *Great Republic* was some 3,300 miles from San Francisco and 2,100 from Yokohama, but her sturdy qualities were such that, in the words of Postmaster General Randall, she was "nevertheless able to proceed on her voyage, reaching Yokohama by the use of one wheel, and attaining, under these adverse circumstances at one of the stormiest seasons of the year, the remarkable speed of 173 nautical miles a day." A third ship was added to the branch line by 1869, the comparatively new 1,915-ton *Oregonian*, and a fourth and fifth in 1871, the 1,736-ton *Ariel* and the 1,870-ton *Golden Age*. By then there were four sailings monthly between Shanghai and Yokohama.

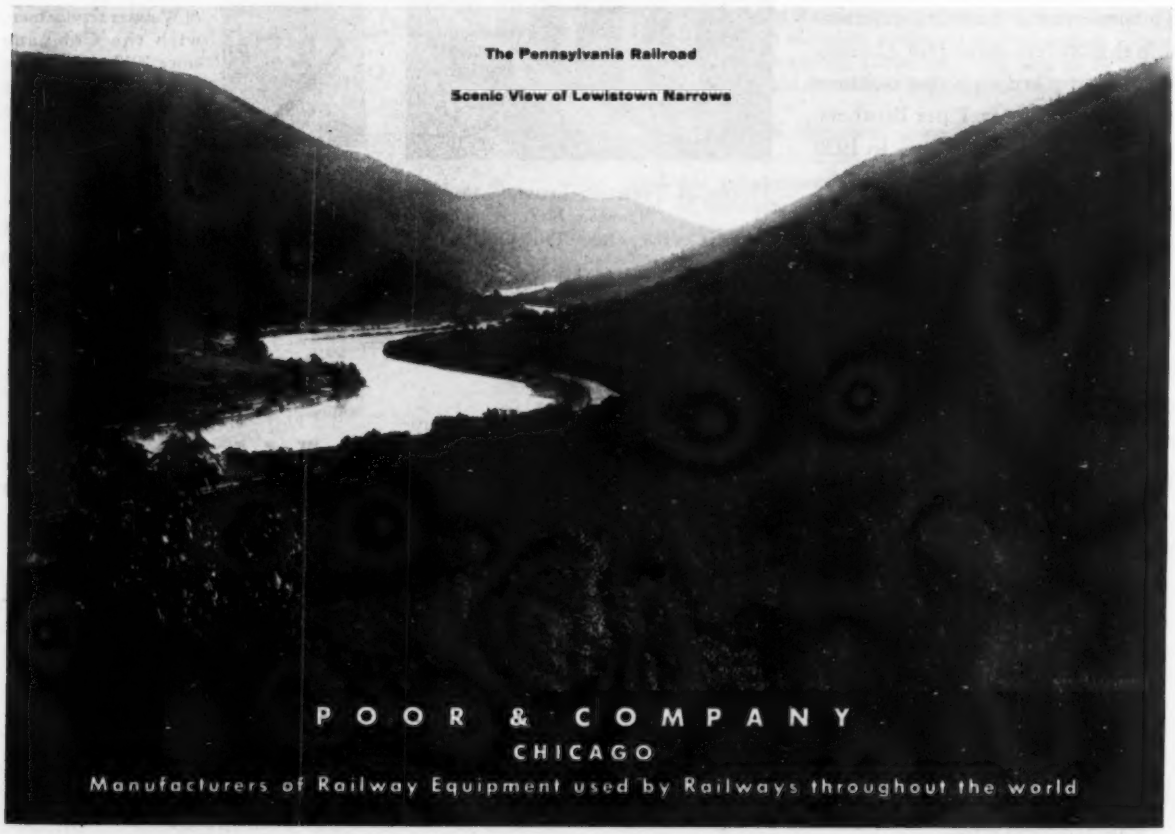
Semi-Monthly Schedules and the Introduction of Iron Screw Liners

On her first two voyages from San Francisco, *Colorado* carried 2,473 letters and 5,967 newspapers, the total postage collected thereon, at 10 cents and two cents, respectively, being $366.64. The average figures for the first ten outward voyages to the Orient were equally modest, *viz.:* 1,913 letters and 2,185 newspapers, yielding an average postal revenue per voyage of but $203.09. In mid-June of 1869, however, the opening of the trans-continental railway brought about a sharp increase in the volume of postal traffic handled via Pacific. During the fiscal year 1870–1871, for example, the number of letters sent westbound from San Francisco was four times the total sent during 1867–1868, the number of newspapers sent was sevenfold greater, and the postal receipts thereon amounting to $19,596.90 represented an increase of nearly tenfold.

President Grant's first Postmaster General, John A. J. Creswell of Maryland, therefore urged that the schedules of the trans-Pacific mail steamers be stepped up to semi-monthly sailings, and Congressional authority for a subsidy to do so was embodied in Sections 3 and 4 of the Post Office Appropriation Act of June 1, 1872. This Act required, ". . . that all steamers hereafter accepted for such service shall be of not less than 4,000 tons register each, and shall be built of iron, and with their engines and machinery shall be wholly of American construction, and shall be so constructed as to be readily adapted to the armed naval service of the United States."

The Pacific Mail was the sole bidder responding to the advertisement of the Postmaster General issued on June 5, and by the terms of a contract dated August 29, 1872, the Company undertook, in return for an additional $500,000 per year, ". . . . for a term of ten years from

(*Continued on page 174*)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ORIENT MAILS "VIA PACIFIC"

(*Continued from page 172*)

and after the first day of October, 1873, . . . to despatch an additional steamship from San Francisco on the 16th of each month, or upon such other days as may hereafter be selected, with the approval of the Postmaster General, the departures to be always so arranged as to alternate at equal or regular intervals with those of the present monthly line during its continuance."

In May of 1872, when it appeared probable that Congress would grant the extra subsidy for additional trans-Pacific service, the Pacific Mail began to run extra steamers once a month on its own initiative. For the mails so carried, "sea-postages" were allowed by the Government to the Pacific Mail "as full compensation under the provisions of the general law fixing the rate of compensation for the sea-conveyance of mails." Reimbursement continued on this basis through 1873, 1874, and into 1875, for it was not until July, 1874, nine months after the stipulated time for the commencement under contract of the additional subsidized service, that the Pacific Mail's required iron steamers were ready — *City of Peking* and *City of Tokio* 5,500-ton liners costing more than $1,100,000 apiece and driven by screws rather than paddle-wheels.

The Postmaster General was tolerant about the delay, and the Attorney General supported his contention that the new contract was still in force. But the Pacific Mail was under fire for illegal lobbying in connection with the contract, and in March, 1875, these complaints caused a repeal of its additional subsidy. By the following July, the Pacific Mail went back to a monthly schedule, and alternated its sailings with the monthly departures of the new Occidental and Oriental Steamship Company which began trans-Pacific service in that month.

Coincident with the inauguration of semi-monthly sailings, postal traffic via Pacific attained new higher levels, which were maintained throughout the 1870's. The time saved by the Union Pacific Railway more than offset the corresponding quickening of the route via Suez by the opening of the canal to commercial vessels in November, 1869, and the substitution of Brindisi (at the heel of the Italian boot) for Marseilles as the European port for the reception and despatch of Indian, Australian, and Far Eastern mails in 1871, when the Mt. Cenis Tunnel (begun in 1857) became available for traffic. English merchants at Yokohama, for example, preferred to send their letters to London by way of San Francisco not only because the rate was less (from the spring of 1876, 10 cents per half ounce compared with 28 cents), but because the letters were delivered in 43 days as contrasted with the 50 days required by way of Suez.

Some Finances

During the first five calendar years of operation (1867 to 1871), the subsidy actually paid to the Pacific Mail totalled $2,500,000, while the postage receipts amounted to only $69,744. Postal receipts, however, were not the sole tangible usufructs the government derived for, according to official estimates, the establishment of the line brought to the national Treasury during this period over $3,000,000 of extra revenues, viz.: $2,884,000 increased customs duties at San Francisco, $162,000 gross

(*Concluded on page 176*)

Rouge, so named because it is located on the River Rouge in Detroit, is the world-famous main production plant of the Ford Motor Company.

It is famous for other reasons than its huge size and great production achievements. It also has the largest steam electric power station serving any industrial establishment, anywhere.

When the Rouge Power Station was built back in 1920, it began setting new records immediately by installing boilers capable of producing 200,000 lb of steam per hour, the largest boilers ever built up to that time, and firing them with pulverized coal — then considered a revolutionary method. Yet only five years later Rouge began rebuilding four of its eight boilers to take advantage of water-cooled furnaces and other new developments which resulted in more than doubling their capacity.

But this was only the beginning of the Rouge modernization program. In 1930 Ford took the drastic step of completely discarding two of the boilers installed only 10 years before and replacing them with two 1400-lb pressure boilers, each capable of producing 700,000 lb of steam per hour. These were by far the largest super-pressure boilers built up to the time. By 1939 the remaining two original boilers had been replaced with 1400-lb pressure units, each of which was capable of producing 1,000,000 lb of steam per hour.

Thus, within twenty years, the most modern industrial power plant of its time had rebuilt or replaced all its original boilers, had nearly quadrupled its original capacity and had substantially increased its efficiency. And all this was accomplished within the same floor space which the eight original units had occupied.

Because it so impressively exemplifies contemporary progress in the field of steam generation, the Rouge Power Plant is not only a source of pride to its owners but also to Combustion Engineering, the supplier of boilers and all related equipment for Rouge from its inception through every stage of its modernization to date.

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ORIENT MAILS VIA PACIFIC

(*Concluded from page 174*)

receipts from stamp taxes, $68,000 duty on coal consumed by the steamers, and $71,340 tonnage taxes.

The Government's justification for an annual subsidy of $500,000 — a not inconsiderable sum in those days of eighty years ago — to the Pacific Mail Steamship Company to pioneer a mail steamship service connecting the United States and the Far East did not rest, therefore, even in the initial stages, upon mere faith in the potentialities the venture had for the enhancement of our national prestige.

VACUUM IN THE HOME

(*Continued from page 160*)

In 1905 German hygienists performed experiments to test the efficiency of an English model vacuum cleaner. In these trials wet gelatine plates were exposed to show a comparison between the amount of dust which settled in ordinary beating and sweeping and that raised by the new vacuum cleaner. The machine is described as if it were some newly discovered variety of plant life. Favorable tests notwithstanding, the hygienists concluded that vacuum cleaning failed to save either time or labor. [18, 19]

In keeping with the general trend of household mechanization the initiative then passed into American hands. The Americans support the candidacy of David T. Kenney who "installed the first mechanical cleaning system in which the vacuum alone was used as a cleaning agent" [20] in the Frick Building, New York City in 1902. Kenney's pioneering patent was granted by 1901 and is said to have been lying in the Patent Office for years before. Here the chronological trail becomes rather blurred, but it seems that America pioneered the stationary models while England and France developed the early mobile ones.

In the uncertainties of early development, one thing is certain, however. The American vacuum cleaner industry — whether it manufactured portable or stationary machines — became licensees of the Kenney patents, the validity of which was upheld in official inquiry into the vacuum cleaner industry. "The Kenney patents are the basic vacuum cleaner patents that have been litigated and upheld by the courts." [21]

Vacuum Becomes a Household Tool

The circle closes some six decades after the advent of the first portable machines in which suction was tried. In the interval the type of cleaner having bellows and revolving brushes had received most attention. In 1917, (the year in which a large mail order firm introduced the portable electric model) the public was assured that the

(*Continued on page 178*)

[18] G. Richou, *Nettoyage sanitaire par le vide, La Nature* (Paris, 1908), p. 577.

[19] Dr. Berghaus, *Der Vacuumreiniger, ein Apparat zur staubfreien Reinigung der Wohnraeume, Archiv fuer Hygiene*, vol. 52 (Muenchen, 1905).

[20] Cooley, *op. cit.*, p. 13.

[21] Report of the Federal Trade Commission on the House Furnishing Industry, p. 6 (Washington, October 5, 1925).

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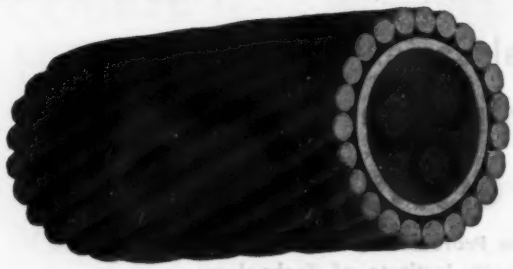

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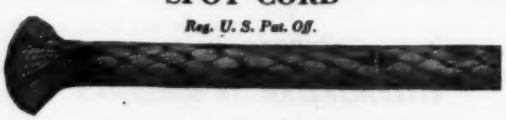

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VACUUM IN THE HOME

(*Continued from page 176*)

bellows machine "accomplishes practically as much as an electric cleaner at much less cost."[22]

After a lapse of several decades the standard types of vacuum cleaner were developed within a few years. During 1901 and 1902 there emerged the first satisfactory stationary plants in America and England. The first portable vacuum cleaner is said to have materialized in 1905,[23] but this American machine, with large turbine fan and motor mounted on a chassis, was still rather bulky and more nearly resembled the French semi-mobile machines than the later and lighter household appliances. Two years later, in 1907, patent specifications were submitted for a more portable machine tending toward the now standard form.[24] The fan revolved around a vertical spindle coupled directly to the motor, just as in Tesla's electric fan of 1889. The carefully shaped motor casing was made to carry a swivelled handle. In brief, the carpet sweeper had become not only mechanized but electrified. Subsequently the main trend was to be directed toward simplifying and reducing the number of parts as James M. Spangler, the inventor, stated in his next patent issued in 1915: "The object of this invention is to provide a construction which will be composed of a few simple parts, put together in a practical mechanical manner."[25] In short, in the development of the electric vacuum cleaner, hardly more than five years elapsed from the advent of the cumbersome units to the creation of a portable form which was so widely adopted as to make it an everyday household tool.

Competition of Water and Electric Power

The specialists were skeptical of the trends which had become quite marked by the end of the first decade of the Twentieth Century. As late as 1912 some skeptics thoroughly disbelieved that smaller and more dependable types were not possible. One of them makes the point particularly clear by refusing to discuss portable types.[26] Another, who treats the vacuum cleaner question of his time most thoroughly, is somewhat less emphatic, remarking in 1913 that "it will be the survival of the fittest."[27] He believed that the vacuum cleaner "is at the height of its career, like the automobile."

The skepticism of the experts was not wholly unfounded as is evidenced by the diversity of attempts to find an adequate motor and a satisfactory form of portable mechanism. In 1910 the stationary installations, with suction pump and dust separator in the cellar, were used mainly in residences. A catalog of the time shows

(*Continued on page 180*)

[22] Catalogue of the Montgomery Ward Company, 1917, p. 704.

[23] Illustrated by M. S. Cooley, *op. cit.*, p. 16. Inventor: Dr. William Noe, San Francisco.

[24] U. S. Patent 889823, June 2, 1908. James M. Spangler. He already shows the dust bag.

[25] U. S. Patent 1151731, August 31, 1915. This is the machine which was made over to the Hoover Suctionsweeper Company, a corporation of Ohio. In a sequence of further improvements the present standard type was developed.

[26] Arthur Summerton, *Treatise on Vacuum Cleaning* (1912): "We shall confine this treatise to the stationary system as we believe satisfactory results in cleaning cannot be expected from portable machines."

[27] M. S. Cooley, *op. cit.*, p. 20.

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VACUUM IN THE HOME

(*Continued from page 178*)

the master of the house in the parlor with the butler giving his coat a few strokes with the suction nozzle fixed to the end of the vacuum hose. On the floor above the maid is performing a similar operation on the lady's hat, and other domestics are cleaning the furniture and carpets. The vacuum cleaner and prosperity were soon identified as a single concept.

In the period around 1910 water motors or other prime movers were also used to power vacuum cleaners as well as washing machines. Water-powered motors were always used in stationary installations working by suction alone. Ease of operation of such equipment was stressed in such advertising copy as: "All you have to do is push a very light tool over the floor." With a thrust at the portable electric models the user was assured that the water-powered type "never wears out; will last as long as your building . . . better results without any machinery . . . no dirty bags with germs to empty. . . ."[28] Another appliance, the Water Witch, was featured as being light and almost entirely built of aluminum. The Water Witch "pumps by means of a water wheel" and can be "set temporarily in the kitchen sink or bath tub." The dust sucked up was drawn through the pump and was carried away by the water.[29] Enticing accessories, such as a massage vibrator outfit, or hair-drying apparatus, were delivered with some devices. The user of one of these was advised that "the heaviest head of hair is quickly, thoroughly, and hygienically dried after a shampoo, by means of the current of pure fresh air from the exhaust."

Here were ample indications that the path of future development was not clearly discernible. Promoters of the water driven cleaners held the wrong cards, however. Only one way held the true promise of the future — use of the fractional horsepower electric motor. When, in 1909 — only a year after the granting of the basic patent — the Hoover Company countered with a full-page advertisement in the *Saturday Evening Post*, it seemed deliberately to trump into the claims of the Water Witch. The distinctive Hoover motto was, "Sweep with electricity for three cents a week." In spite of the haughty claim, "We are now turning out hundreds of machines a week, the demand is enormous," the number of rival attempts, a few of which have been mentioned, show that the success was not unmitigated. The path of electric drive was the right one.

The two basic types, that of 1859 and that of 1860, are represented almost equally in the portable electrified models of today. The suction type of 1859 survives in today's tank type of vacuum cleaner[30] in which the operator holds only the suction nozzle, as in the earlier, stationary types while the motor and dust-bag cylinder slides on the carpet on runners. The handle type of vacuum cleaner, in which the rotating brushes, motor, suction intake, dust bag and handle form a light trolley unit, follows the design of 1860 in which suction is combined with brushing.

(*Concluded on page 182*)

[28] "The Hydraulic" catalogue, Collection of Tom J. Smith, Jr.
[29] Vacuum Hydro Company, New York, catalogue, Collection of Tom J. Smith, Jr.
[30] As in the Electrolux vacuum cleaner.

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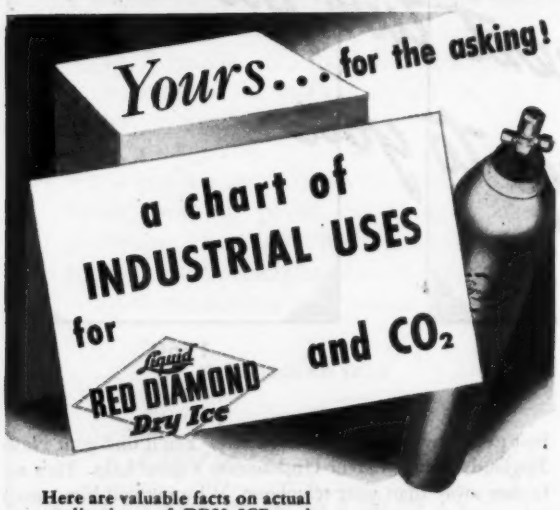

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VACUUM IN THE HOME

(*Concluded from page 180*)

The easily portable vacuum cleaners gave an extraordinary opportunity to high pressure salesmanship. Going from door to door with his machine, the salesman sold his product chiefly on pay-as-you-go basis by which American mass production of all manner of goods—from the vacuum cleaner to the automobile and the house—became financially possible. The mail order houses, founded in the 1870's, also owe their tremendous growth to this credit system.

Four years after the specialists pronounced themselves skeptical, the light weight models had already become an American institution; in the mail order catalogs of 1917 they appear at the low price of $19.45.

Earlier and more conspicuously successful than all other mechanical household appliances, the vacuum cleaner, which can be put away in any broom closet, made its way throughout the world. By 1929 the conservative *Encyclopedia Britannica* was able to state, "The light portable type is by far the most popular and represents 95 per cent of all vacuum cleaners in use." Except in America, its popularity greatly exceeds that of the mechanized washing machine. The vacuum cleaner firmly established itself as a household tool at the beginning of the period 1918 to 1940; a period of mechanical accomplishment which is well called the "Time of Full Mechanization."

TREND OF AFFAIRS

(*Continued from page 152*)

du Pont, '84, would be inscribed over one of the two main fore-courts.

Before his death in 1900, Augustus Lowell's two sons, Percival and Abbott Lawrence, became his colleagues on the Corporation, respectively in 1885 and 1896. Percival's interest in Technology affairs was especially active after 1894 in which year his remarkable observations of Mars and its canals began at the Lowell Observatory at Flagstaff, Arizona, and where, coincident with the outbreak of World War I, he discovered and located, but never saw, a planet to be observed in 1932 by his successors who named it Pluto. From 1902 until his death in 1916, Percival Lowell was a member not only of several Corporation Visiting Committees but also of the Technology Faculty as non-resident professor of astronomy.

The Corporation span of Percival's younger brother, the late President Lowell of Harvard, extended nearly 47 years—the longest of any Lowell, with the single exception of Francis H. Williams, '73, who served from 1882 to 1935, the longest recorded for any member of the Institute's Corporation. He began under the administration of General Francis Amasa Walker; was on the Executive Committee five years during the Crafts administration; was on the Visiting Committee on Literature, History, and Political Economy from 1896 to 1912 when, at the request of President Maclaurin he joined the Visiting Committee on Architecture, an assignment which was to last until 1940. In the latter year, he became one of the original three members of the Visiting Committee on Student Activity created by President Compton, and from 1941 until his death in 1943 he served also as a mem-

(*Concluded on page 184*)

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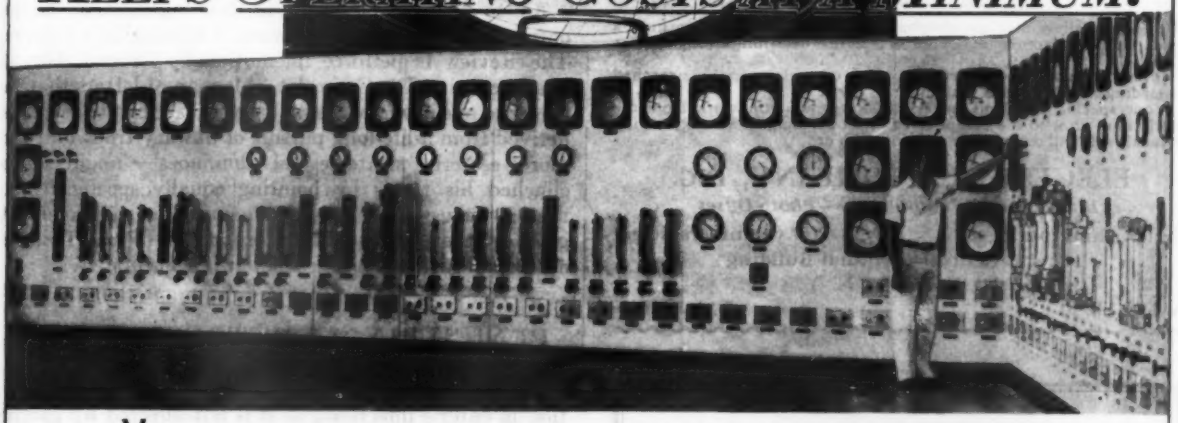

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TREND OF AFFAIRS

(*Concluded from page 182*)

ber of the Visiting Committee on the Department of English and History.

From 1862 to 1943, therefore, that is to say throughout all but four of the 85 years of the Institute's history, one or another of these four Lowells, sometimes two at once and for a while three, were concerned in its governing body. Dr. Greenslet, in an epilogue in which he casts a trial balance between the accomplishments of the Lowells and those of another notable contemporary New England family, the Adamses, concluded that "in education the scales are weighted on the Lowell side." He points with pride to the "210 man-years of service and leadership" given by the Lowells to Harvard in slightly more than three centuries, and adds that their "vision and practical management contributed to the Lowell Institute and the Institute of Technology."

As to the completeness of the educational credit entries on behalf of the Adamses in the author's ledgers, The Review is perforce unemotionally neutral. But it does seem that Dr. Greenslet, able man-of-letters that he is — and one in whom are deftly blended rich philosophies derived from a life-long pursuit of unwary trout and the more esoteric strategies of dominoes — might have clinched his thesis by pointing equally specifically to the 124 man-years of vision and practical management given by the Lowells to the Corporation of M.I.T. in its chartered existence of less than a full century.

PENICILLIN AND STREPTOMYCIN

(*Continued from page 156*)

tion in enteric infections, as it is not affected by gastric juices and passes through the intestinal tract unchanged. Streptomycin can also be applied to the surface of infected body areas. In dry form it is quite stable; solutions deteriorate more rapidly unless kept in the refrigerator.

Streptomycin will not replace penicillin; rather, it will complement its famous predecessor. Penicillin's specific power has been established incontrovertibly in infections caused by Gram-positive bacteria, hence its proven performance in pneumonia, staphylococcic and streptococcic septicemias, gonorrheal infections, and so on. Streptomycin, on the other hand, is particularly

(*Continued on page 186*)

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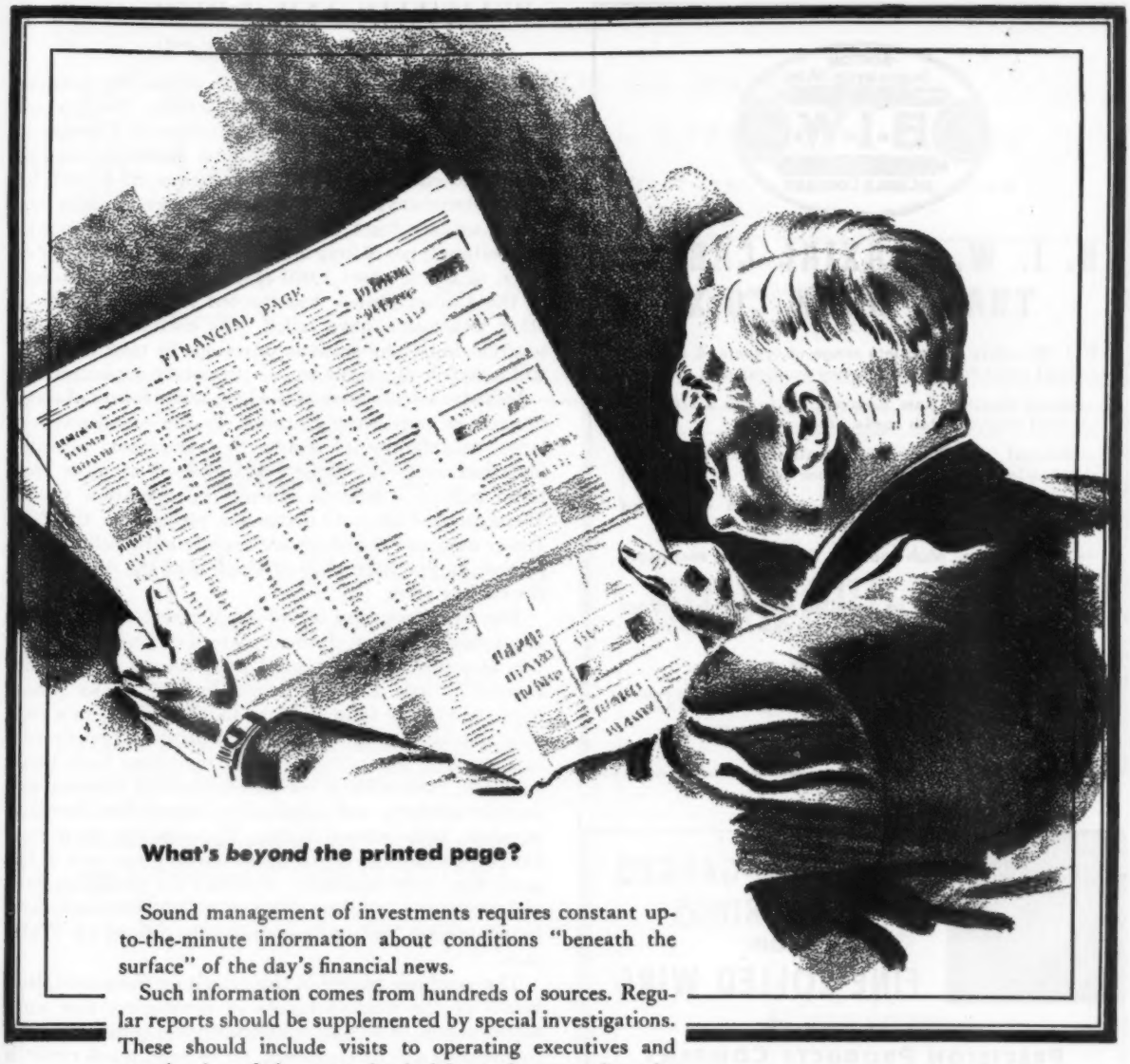

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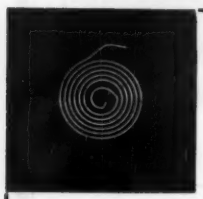

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PENICILLIN AND STREPTOMYCIN

(*Continued from page 184*)

efficacious in combating infections caused by members of the Gram-negative group of bacteria. The co-ordinated study conducted by the Committee on Therapeutic and Other Agents of the National Research Council, under the chairmanship of Dr. Chester S. Keefer has shown streptomycin to be effective in certain infections of the urinary tract, bacteremia, influenzal meningitis, and certain types of lung infections. Tularemia, or rabbit-fever, of which about 1,600 cases are reported annually in the United States, has reacted favorably when all other treatments have failed. The usefulness of streptomycin in *M. tuberculosis* infections in man is largely still a matter of conjecture, as previously explained.

Industry's confidence in the long-range future of streptomycin is convincingly proved by the construction of large manufacturing plants by American penicillin manufacturers. One large plant, valued at more than three million dollars is already in operation in the Shenandoah Valley. Construction projects in the New Jersey area and elsewhere are rapidly approaching completion, and promise mass production of the drug within the coming year.

The manufacturing technique of streptomycin generally follows the now classical pattern of penicillin: selection of a productive strain of *Streptomyces griseus*, submerged growth of the organism in large tanks (whose capacity may be from 1,000 to 15,000 gallons) in a suitable nutritive medium, careful control of temperature and sterility, separation of spent mycelium from liquid substrate, extraction of the metabolite with charcoal and organic solvents, and purification before final low-temperature, high-vacuum drying. The pure dry streptomycin (hydrochloride) is put up in sterile glass vials of the same type now familiarly employed for penicillin, each vial containing one gram of streptomycin base equivalent to one million "S" units as originally defined by Waksman.

The emphasis placed in this article on the accomplishments of the microbiologists in developing new antibiotics should in no way minimize the contributions made by chemists and by engineers. To be sure, much credit is due to the soil-microbiologist, who in the last analysis seeks means of bringing the resources of the soil popula-

(*Concluded on page 188*)

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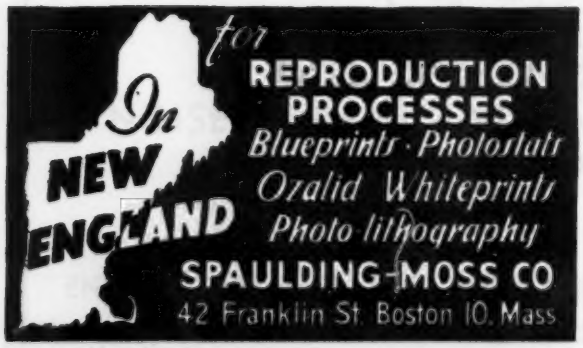

PENICILLIN AND STREPTOMYCIN

(*Concluded from page 186*)

tion to the service of man by isolating and controlling such useful organisms as the *Penicillia* and *Actinomycetes*. However, only through knowledge of the chemistry of penicillin was it possible to incorporate in the fermentation broth, which provides nourishment for the growth of the microbial organism, substances which already contain portions of the characteristic penicillin molecule. These chemical substances, which are referred to as penicillin precursors, are speeding up many fold the effectiveness of bio-snythesis of penicillin by the molds.

In the case of streptomycin, extensive research in nutrition media demonstrated that *Streptomyces griseus* thrives particularly well on a diet of meat extract, while *Penicillium* grows profusely with proteins of vegetable origin. Chemical engineers have provided novel designs for fermentors, filters, extractors, and low-temperature drying equipment; and many ingenious and delicate control instruments have been developed to assure safe and efficient processing of the sensitive substances obtained from mold metabolism.

Microbiologists, chemists, physicists, and engineers working as a team, with pharmacologists and physicians are sure to produce new miracles to help mankind in the years to come.

LOW TEMPERATURE REFRIGERATION

(*Continued from page 162*)

because the magnetic field produced by the current itself will destroy the superconducting state if it exceeds a certain critical value at a given temperature. This fact precludes the possibility of transmitting large amounts of electrical energy over a thin wire kept at low temperature.

Future research now being planned is expected to shed light not only upon these little understood phenomena but also upon the important general problem of the solid state. The possibility that superconductors may play a useful role in detecting minute quantities of radiant energy is also being investigated experimentally.

The helium cryostat[4], recently developed at M.I.T., is expected to give a considerable impetus to low temperature studies because of the flexibility of operation over a wide temperature range. This cryostat provides an experimental chamber which can be cooled to any temperature level from ambient to within four degrees F. of the absolute zero. Gaseous helium, the refrigerant, is circulated by a compressor at relatively low pressures. The stream is divided into three fractions, the first two of which are expanded with the performance of useful work at the indicated temperature levels, and the third isenthalpically (at constant heat content) at the boiling point of liquid helium, −452° F. If a still lower temperature is desired, operating conditions are adjusted for the production of a quantity of liquid helium which gathers on the floor of the experimental chamber. The rate of production is approximately three quarters of a liter per hour. When a sufficient quantity has accumu-

[4] Collins, S. C., "A Helium Cryostat." *Phys. Rev.* 70, 98, July 1–15, 1946.

(*Concluded on page 190*)

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LOW TEMPERATURE REFRIGERATION

(*Concluded from page 188*)

lated, the compressor is converted into a vacuum pump, by turning appropriate valves. Evaporation of the liquid helium under reduced pressure quickly brings the temperature down to about −456° F. Any gas can be liquefied and delivered to the exterior.

In 1926 Giauque [5] and Debye [6] independently predicted that, at very low temperatures, the internal energy of certain paramagnetic salts at a given temperature and in a strong magnetic field would decrease substantially as the intensity of the magnetic field is decreased. The experiment was carried out successfully in 1933. Gadolinium sulphate placed in a magnetic field of 8000 gauss and cooled by helium, boiling under reduced pressure, suffered so great a loss of energy that its temperature fell to within one quarter of a degree of absolute zero when the magnetic field was suddenly removed. In later experiments, temperatures within a few thousandths of a degree of absolute zero were attained. As a method of cooling, adiabetic demagnetization of paramagnetic salts is of interest only in the region below the boiling point of helium, but scientifically, at least, it is of very great importance because it makes available a temperature level not otherwise attainable at the present time.

The Research Laboratory of Electronics has recently acquired a second helium cryostat of the type described above. With the facilities already in existence in the Magnet Laboratory and a supply of liquid helium, it will be possible to perform experiments at temperatures very close to the absolute zero by the adiabatic demagnetization of certain salts. The Department of Physics is preeminently equipped for the study of low temperature physical problems.

For several years, low temperature calorimetric measurements have been carried out in the Department of Chemistry from room temperatures to that at which hydrogen solidifies.

In the Laboratory of Cryogenic Engineering of the Department of Mechanical Engineering, apparatus is being assembled for the further study and development of low temperature equipment such as turbo expanders and air rectifiers, for the study of some of the thermodynamic properties of air at low temperatures, and the effect of low temperatures upon the mechanical properties of certain materials.

Much of the equipment will be available for laboratory instruction of students interested in low temperatures.

[5] Giauque, W. F., "A Thermodynamic Treatment of Certain Magnetic Effects." *Jour. Am. Chem. Soc.*, 49, 1864 (1927).
[6] Debye, P., "Einige Bemerkungen zur Magnetisierung bie Tiefer Tempertur," *Ann. Physik*, 81, 1154 (1926).

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